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THE SURGICAL CONSTRUCTION OF 80 CASES OF ARTIFICIAL ESOPHAGUS

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CICATRICIAL strictures and obliterations of the esophagus following chemical burns are not common, but they attract attention and interest because, in the majority of cases, they concern young adults or children doomed either to continual painful dilatations or to a miserable gastric fistula existence.

The majority of 80 patients operated upon and over 200 examined in consultation and treated for strictures of the esophagus were between the ages of 17 and 20 years. Many cases resulted from suicidal attempts of young women; several occurred in young Red Army soldiers of the engineering corps who drank caustic soda from alkaline accumulators mistaking it for water; and not a few children were treated who had drunk strong alkaline washing solutions, or the sulphuric acid from the bottles placed between window panes to keep them clear of frost during winter months.

To analyze and discuss the principles and methods of treatment of fresh esophageal burns is not the purpose of this paper. Dilatation of strictures by means of semihard bougies and elastic dilatation by means of rubber tubes are well known methods. They are used as preliminary steps in the treatment of cicatricial strictures of medium gravity. Often seemingly impassable strictures yield to the action of semihard conic dilators, and many times remarkable results have followed elastic dilatation of extensive strictures of the esophagus by means of rubber tubes inserted along a swallowed thread, introduced through the mouth or through the gastric opening.

However, these methods do not solve the whole problem. In many cases such treatment is not successful, either because of the length of the cicatrix along the esophagus, the thickness of the cicatricial tissue, or because of complete obstruction even to the passage of the thinnest ureteral catheter. In such instances conservative treatment does not succeed or simply cannot be applied.

It has been said that stricture of the esophagus with complete obstruction is practically never found; that all strictures can be cured by persistent, skillful dilatation. Therefore, it has been stated that there are no direct indications for the surgical operation of constructing an artificial esophagus. In our experience, however, we have encountered many cases of impassable strictures in the cervical portion of the esophagus, or even in the pharynx, which terminated in a blind sac, inside which neither a thin probe nor direct esopha-

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goscopy could detect the smallest fistula leading downward.

Presumably if proper measures are instituted immediately after the burn has taken place it will be possible to secure a direct filiform passage from the pharynx into the stomach. However, it should be stated that first of all, it often happens that the stomach too has been burned by the caustic soda and may require an emergency operation before it becomes clear what the fate of the burned esophagus will be. Sometimes, the degree and extent of the gastric surface burned are so great that the stomach can be considered a total and irreparable loss. If one succeeds with great difficulty and risk in fastening an anterior gastroenterostomy upon the remaining part of the fundus (which is sometimes found in the deepest part of the subcostal space in the form of a thin-walled, swollen balloon the size of an egg), no gastric wall remains for the adjustment of the gastrostomy and the fastening of the rubber tube.

Examples of severe stomach burns in which the esophagus remains intact are rather numerous. In such cases the caustic soda has been swallowed down very quickly, has passed through the esophagus without injuring it, and has remained entirely in the stomach because of the spastic contraction of the pylorus. However, as these cases have no direct connection with the problem of burns of the esophagus, we will not discuss them at this time.

A second point is that we cannot make up for the time lost or correct the mistakes of others who treated the esophageal burns when first received. In most cases our patients came from other hospitals, far distant from Moscow, some months or even years after the accident; they are fed through gastric fistulas as they have absolutely impassable esophageal strictures.

The question of dilatation of recent esophageal burns still remains unsolved. Professor A. N. Kryoukov, who has had considerable experience in the medical department of our Institute, declares that (1) early dilatation should be applied only in the cases of moderate general intoxication; and (2) passability is presumed to be secured in those cases in which the mucous membrane is not burned through-out but only in limited parts of the esophagus. However, when the necrotic mucous membrane sloughs away from top to bottom "as a stocking" or over a considerable length of the esophagus, one cannot rely upon a sufficient regeneration of the mucous membrane, even with early energetic dilatation with soft bougies.

Finally, the third objection concerns the late results after dilatation of strictures. Our experience with esophageal foreign bodies has shown that a large number are found in patients suffering for many years from partial strictures of the esophagus as a result of burns.

The success or failure of dilatation of old esophageal strictures depends first and foremost on the degree of narrowing, the extension of the stricture itself along the esophagus, the kind of cicatricial changes in the esophageal wall, and the adjacent mediastinal cellular tissue. The gravity and extent of esophageal lesions depend in the main on the quantity and concentration of swallowed liquid.

By the early application of soft rubber dilators or of flexible bougies passage can be secured and excessive stricture prevented only in cases of local or superficial burns of the mucous membrane. In the presence of complete necrosis of the whole thickness of the mucous membrane, neither intelligently used prostheses nor early dilatations can secure regeneration of the mucosa or prevent cicatrization and wrinkling of the naked muscular wall.

Therefore, conservative treatment is practically hopeless not only in cases of complete obliteration of the esophagus but also in the ever recurring severe strictures which show improvement only for short periods and exhibit pronounced general and local reactions to dilatation. One must choose between the patient existing with a permanent gastric fistula or having the operation of antethoracal esophagoplasty.

CHOICE OF THE METHOD OF OPERATION

The antethoracal cutaneous plastic proposed by Bircher in 1894 is quite expedient and involves a lesser number of operative stages. The only dangerous moment of the procedure comes when the upper part of esophagus is exposed for the neck stoma. In fact, the mobilization of the pharynx or of the cervical part

of the esophagus, to say nothing of the dissection and closure of the distal end, introduces the possibility of infection of the cellular tissue of the mediastinum. But this cannot be avoided in any other method of esophagoplasty.

The objections to this method in so far as there may be a lack of peristalsis in the cutaneous intestinal tube can now be absolutely refuted; our experience is now sufficient to prove that the cutaneous tube allows the passage of food of any kind in a passive but satisfactory manner. Rarely do esophaguses constructed of jejunum allow the rapid passage of swallowed food. More often, the unavoidable surplus of intestine in comparison with the length of the mobilized mesentery causes, if not a stasis of food, at any rate a varying multicurved course along the antethoracic region. Peristalsis of the intestine is energetic, and if no obstacles are present, such as strictures or curves along its course through the abdominal aponeurosis or in the abdominal cavity, evacuation will be sufficient but may be a little slow.

Two other defects of the Bircher operation may be mentioned: first, the capricious behavior of the definitive gastric stoma that is created to make connection with the lower end of the cutaneous tube; and, second, the difficulty and insecurity of the plastic operations required to close the lower end of the cutaneous esophagus.

What could be easier than to make a definitive lip-like gastric fistula when one can bring out, through a corresponding opening in the abdominal wall, the gastric wall, fasten it without strain, and carefully join and sew together the mucous membrane with the skin? It is quite extraordinary but such a fistula displays an irresistible tendency to narrow. It often happens that a well made fistula will, in a month or two, become more and more narrow, requiring repeated excisions of circular callous cicatrices. For fear of possible narrowing, the fistulas may then be made too large. This practice has resulted in a rich flow of gastric juice, escape of food into the dressing, and maceration of the skin not only around the fistula but also within the limits of the whole dressing. Sometimes painful dermatitis developed and resembled a large belt around the abdomen, sides, and even back of the patients. Patients were afraid to take food because of the gastric secretion which inevitably escaped and burned the skin like fire. Patients became very thin, could not sleep, and did not know how to lie down without irritating the inflamed skin.

The quite natural tendency to free the patient as soon as possible from such suffering by joining the fistula with the cutaneous tube is made difficult for two reasons: First, as has been mentioned, large gastric fistulas may unexpectedly become so much narrower that new operations to enlarge them are made necessary; second, often the abdominal skin surrounding the fistula has become so irritated that the very thought of a plastic junction of the lower end of the artificial esophagus is out of the question and operation must be delayed until the dermatitis can be brought under control by the application of ointments.

But even when the condition of the skin has improved, the fistula finally formed, and the tendency to become narrower has disappeared, any method to close the lower end of the artificial esophagus can result in some failure, for example, in a small but complete fistula. It is extremely difficult to close such a fistula; it is absolutely impossible to set it up by twisting in the separated edges inside and by sewing the mobilized skin over it. The failure is unavoidable and inevitable. Instead of a small fistula a large one will be formed, and there will be an even larger quantity of dead cicatricial tissue surrounding it. Every new operation among these cicatrices makes less and less promising the chance for final success.

These stages of the Bircher operation have become real causes of despair for the surgeon as well as for the patient. Many patients have been subjected to countless operations and have become disfigured by the many cicatrices and the application of all kinds of Filatov grafts taken from the thighs and forearms.

If in connecting the lower end of the cutaneous tube with the gastric fistula one joins the side flap obliquely, the coincidence of the deep sutures on the tube, along the whole line of exterior sutures, is avoided; and failure of the fistula happens much less often. We use this as the method of choice not only in opera-

tions upon the upper part of the esophagus and when the pharyngeal stoma is joined with a transplanted section of intestine but as well for the closing of the cutaneous segment if the intestine does not reach high enough on the neck. The skin of the neck around the pharyngeal stoma is very seldom macerated and the digestive action of the saliva on the catgut is insignificant. Therefore, plastic closure of the upper part of the cutaneous esophagus occurs in most cases without the formation of complete cicatricial defects, and is successful.

It should be emphasized that unexpected repeated narrowing of the gastric fistula can take place after its closure into the artificial cutaneous esophagus. Then operations for the excision of the cicatrices are necessary and the outcome of these repeated plastic procedures seems even more doubtful because vascularization of the areas involved has become insufficient as a result of the former operations. In connection with all this, it is quite clear that surgeons who have experienced all these difficulties are not tempted by the seeming simplicity of Bircher's operation but rather prefer to choose other methods which promise fewer difficulties and would seem to assure better results.

Some ingenious modifications of Bircher's operation should be mentioned. Riesenkampf begins the construction of the esophagus, not by preparing the cutaneous tube extending from the neck to the epigastrium, but by forming both definitive stomas — the pharyngeal and the gastric. These stomas should be patiently observed and should undergo all necessary corrections if they show any signs of narrowing. When it is clear that both openings have become stable and will permit the passage of any kind of food, Riesenkampf closes them at once into the cutaneous tube which he separates by one oval incision, covering half the circumferences of both stomas and, at the same time, building the entire cutaneous tube on the breast and neck. The twisting-in and suturing of the mobilized edges of this flap enclose the whole length of the cutaneous tube and both its ends. The enormous oval defect of the skin is then covered by drawing together the greatly mobilized lateral surfaces of the skin.

Some years ago, when we made our first 6 artificial esophaguses, using the Bircher method, we began the operation by building the whole cutaneous tube so as to accomplish the most aseptic part of the construction on an absolutely clean skin. Perhaps that is the reason why we did not have the slightest infection and both the interior tube as well as the covering skin healed perfectly. In the Riesenkampf method, the enormous cutaneous plastic operation is done on a patient having two stomas. In any case the skin around the gastric opening is macerated and it is doubtful that it can undergo sufficient preoperative cleansing. If, as is quite possible, infection should start under the sutured skin near the gastric stoma, the phlegmonous process would develop upward along the entire cutaneous tube. The entire plastic procedure would then fall asunder and the cutaneous flaps would revert to their former places after the necrotic cellular tissue had moved away. It would not be easy to repeat such an operation on the same patient because of the risk of activating a dormant infection in the large cicatrices. Success after a second operation would doubtlessly be less probable than after the first attempt. Even worse, if one hesitated to repeat an operation performed after the method of Riesenkampf, because he feared to mobilize large cutaneous flaps along the entire zone of a recent infection, might not the same reflections make it difficult for him to perform an operation done in accordance with any other method? Personally we have never used the method of Riesenkampf because in case of failure no other method could be used and the patient would be irremediably disfigured.

The method of Riesenkampf combines in one single operation the three separate stages of the classic method of Bircher. The modification introduced by J. Jianu, however, is concerned only with the method of constructing the internal cutaneous tube. A flap is cut from the abdominal skin in the shape of a rectangle with an upper base. This cutaneous flap sutured together is bent over and inserted into the subcutaneous tunnel on the chest. If this subcutaneous tube is not long enough to reach up to the neck, Jianu recommends constructing a second one from the scapular re-

gion, bringing this tube across the shoulder, and introducing it so as to meet the first one in the same subcutaneous tunnel. At the junction of the two cutaneous tubes the tunnel is opened by means of a small transverse incision and the open ends of both tubes are sutured together around their entire circumference.

By the use of this method the formation of cicatrices on the chest is avoided and also the method could be used even to lengthen the upper end of the intestinal esophagus if in a slender man there is not enough skin for a cutaneous plastic in the clavicular zone or under it. However, the vascularization of the transposed cutaneous tube through the only remaining narrow part of the rectangular flap would be less sure the greater the length of the tube. The main difficulties in closing the upper, and particularly the lower, end of the cutaneous esophagus remain the same as in the original Bircher method.

Beck, Carrel, A. Jianu, Halpern, and Rutkowsky used flaps from the anterior wall of the great curvature of the stomach, drawing the newly formed gastric tube into the subcutaneous tunnel across the costal edge. The gastric stoma is thus displaced from the epigastrium to the middle of the sternum. Furthermore, a Bircher cutaneous tube is necessary. At the cost of a large and complicated laparotomy, a few centimeters of a quite safe cutaneous tube are saved. The gastric fistula has the same disadvantages which result from corrosive action of gastric juice on the skin.

Even less tempting are those operations in which the whole, or nearly the whole, stomach is used as plastic material. The reflection of the mobilized stomach, by the method of Fink-Henschen, and the insertion of the pyloric section into the subcutaneous tunnel antiperistaltically affords no particular advantages but does represent a very serious operation.

Even more complicated is the operation of Kirschner: the transplantation of the whole mobilized stomach into the subcutaneous tunnel even as high as the neck in order to make a direct junction with the cervical part of the esophagus. But what is most frightening of all are the difficulties encountered in making the unavoidable anastomosis between the cardiac end of the esophagus and the jejunum.

As is often the case in surgery, good ideas come to different authors simultaneously. Before Cezar Roux in Lausanne in 1907 made the first attempt at total antethoracal esophagoplasty by mobilizing the jejunum with the mesentery, Tavel in Berne recommended the use of a short mobilized intestinal loop instead of a simple gastrostomy to feed patients. One end of the loop had to be joined with the stomach, the other drawn out, thus building a large definitive intestinal stoma. The operation of Roux was welcomed with enthusiasm and immediately found many adherents, particularly in France. But the successes attained with the method were not great, partly because of the difficulties of the operation itself and because of the necrosis of the mobilized large intestinal parts, but mainly because most of the operations were undertaken on cancer patients.

The first successful case was the operation performed in Moscow in 1907 by Peter Herzen. In 4 months he succeeded in making an artificial esophagus for a woman who had poisoned herself with sulphuric acid. Herzen added very important improvements to the methods of Roux: (1) unilateral exclusion of the mobilized intestine with anastomosis instead of bilateral exclusion used by Roux; and (2) the passage of the intestine through a slit in the mesocolon and gastrocolic ligament in order to prevent the possible compression by the transverse colon on the way to the subcutaneous tunnel. Herzen joined the intestine with the stomach by an anterior anastomosis.

The difficulties and risk in mobilizing such an intestinal segment so that it would be long enough for direct junction with the esophagus in the neck caused surgeons to look for compromises. It was Lexer who in 1908 combined the operations of Tavel and Bircher and dissected the intestine with its mesentery as far as possible without the risk of devitalization, and then constructed a cutaneous esophagus. Attempts also were made to use the transverse colon instead of the jejunum, antiperistaltically (Vulliet) or peristaltically (Kelling). Figures 1 to 10 illustrate schematically the various operative procedures proposed.

After a critical analysis of the numerous methods one can say that there are two reliable operations: the total intestinal esophago-

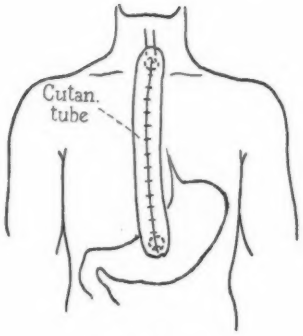

Fig. 1. Birger.

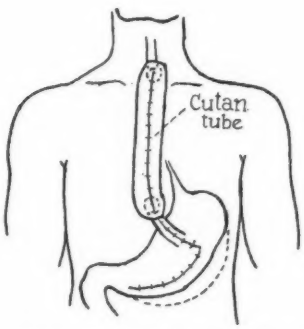

Fig. 2. Beck-Carrel-Jianu-Halpern.

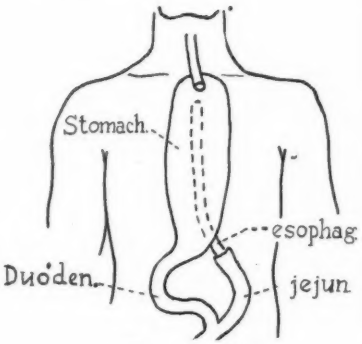

Fig. 3. Kirschner.

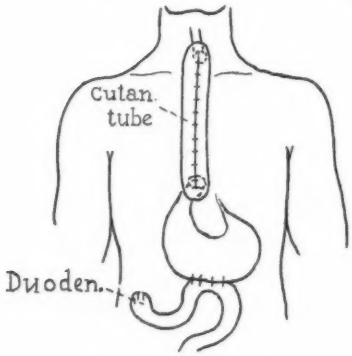

Fig. 4. Fink-Henschen.

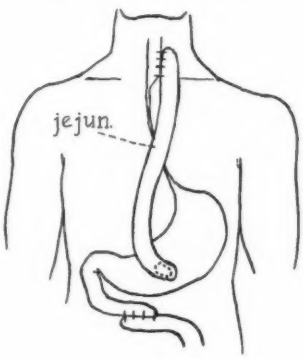

Fig. 5. Roux.

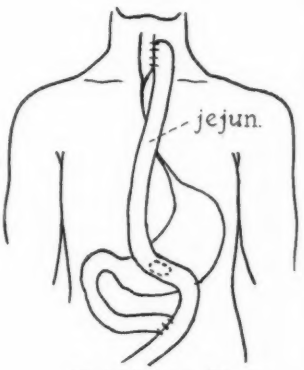

Fig. 6. Peter A. Herzen.

Figs. 1 to 10. Schematic drawings of the various operative procedures.

plasty of the Roux-Herzen type and the combined operations of Wullstein, Lexer, Blauel. One has to choose between them, the choice depending upon the peculiarities of the individual case. In our own experience the total intestinal plastic of the Roux-Herzen type has been found to come nearest to the ideal. Exclusive of the temporary gastrostomy and the possibility of its closure, the construction of the esophagus itself can be accomplished in two stages. In the most successful cases this may be accomplished in 15 to 20 days, with an interval of 5 days between the transplantation of the intestinal segment on the neck and its junction with the pharynx. Of 14 such operations 4 were completely successful; in 2 other cases in which the direct anastomosis with the pharynx was accomplished in one operation, one was a great success and the other was a failure. Total intestinal plastics can be very difficult, very risky, or absolutely impossible. The difficulties depend (1) on the excessive fat in the mesentery, (2) the narrowness of the mesentery, or (3) on a particularly unlucky disposition of the radial vessels and of the mesenteric arcades. The greater the experience and skill of the surgeon in the dissection of the mesentery and in the manipulation of its vessels, the easier it is to mobilize a sufficient section of the intestine without any special risk. But there are some cases in which the greatest skill is doomed to failure; the arcades are too short, their junctions are extremely thin, the radial trunks are in many places insufficiently developed, unequally distributed, the mesentery is too fat and easily tears. It is a grave risk under such unfavorable conditions to try extensive mobilization.

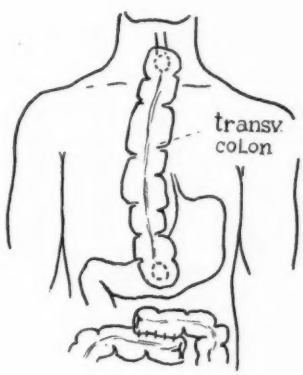

Fig. 7. Vulliet-Kelling.

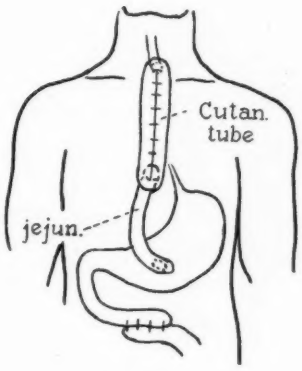

Fig. 8. Lexer.

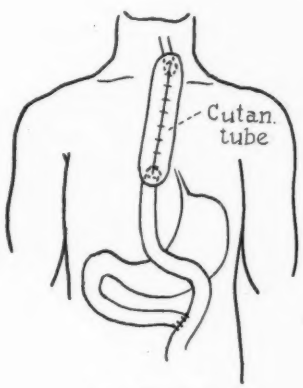

Fig. 9. Wullstein.

It is better to abandon the idea of doing a total intestinal plastic operation and instead to insert into the subcutaneous tunnel up to the middle of the chest a segment of intestine about 50 centimeters in length which has been separated without any particular difficulty. Another important obstacle to the performance of a total intestinal plastic is the strictures of the esophagus which may be situated high in the neck or even in the pharynx. In the presence of such strictures, junction with the intestine is simply impossible because there is nothing with which to make an anastomosis.

These cases are best handled by (1) the Roux-Herzen transplantation of the intestine on the neck as high as possible in order, in later stages, to construct an artificial esophagus at a point where the pharyngeal stoma and the intestinal opening are situated close together; or by (2) a combination of the Wullstein-Lexer operation with a short intestinal segment and the Bircher long additional cutaneous tube.

CHOICE OF OPERATIONS

A total intestinal plastic operation is the most perfect and is practicable in strictures located below the middle of the cervical section of the esophagus. The construction is carried out in two stages excluding gastrostomy; viz.: the exteriorization of the intestine onto the neck and its direct anastomosis with the cervical portion of the esophagus. These two stages should not be united into one because this would involve a tremendous additional risk of infecting the whole subcutaneous tunnel at the point of the anastomosis.

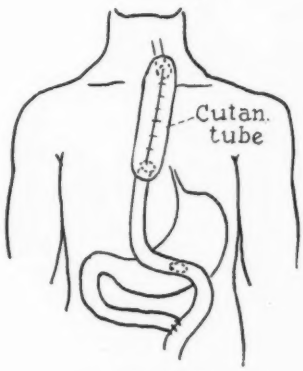

Fig. 10. Blauel.

CASE REPORT

In a lean man, aged 30 years, with complete obliteration of the esophagus at the level of the aortic arch, caused by lye burns, the mobilization of the intestine proceeded easily and smoothly. Very rapidly a segment sufficient to be drawn out above the clavicle was separated. The adjoining vascular arcade was a powerful one, and the radial vessel feeding it was of large size. They were followed, however, by another large and long arcade with a large radial vessel issuing from the root of the mesentery. The adjoining radial vessel was isolated and compressed with an elastic gastric clamp covered with rubber tubes. After it was noted that the blood supply was sufficient, the compressed vessel was dissected, an anastomosis was made, and the intestine was drawn out through a slit in the mesocolon. Assistants had

meanwhile separated out the cervical section of the esophagus. Through the subcutaneous tunnel the intestine was drawn up and out onto the neck. A large anastomosis was done without difficulty. Two small rubber drains were brought out of the corners of the sutured skin; the inner end of one directed to the mediastinum at the neck and the other to the angle between the vertebral column and the mobilized posterior wall of the pharynx.

The postoperative period was uneventful. The drains were left in place for 5 days and showed local suppuration. For 3 days some saliva oozed through the upper fistula, but all secretions had ceased by the 12th day, and by the 15th day the wound was completely healed. The sutures on the abdomen were removed on the 8th day. Intake by mouth was successful and 3 weeks after the operation the patient was dismissed from the hospital.

Despite this first success it was a long time before the one stage operation was repeated. Apart from the obvious risk of infecting the newly made subcutaneous tunnel, there is the added risk of pulmonary complications. Repeated successes, however, and astonishingly uneventful convalescent periods after two stage plastic operations were instrumental in inducing us to renew the temptation. The next operation was not so successful. The mobilization of the intestine was easily performed; there was even a surplus of it on the neck. The cervical section of the esophagus was exposed without difficulty or hemorrhage, and a large anastomosis was made. The drains at the angles were away from the line of the actual anastomosis. The immediate postoperative period was perfectly smooth and nonfebrile. Local subcutaneous reaction on the neck, however, began as early as the 3d day, necessitating removal of some of the cutaneous sutures. Beneath them lay the intestine evidencing violent peristaltic movements. It may have been this ultraturbulent peristalsis which drove the local infection inward from the neck wound along the fresh subcutaneous tunnel as far as the epigastrium. Numerous wide incisions had to be made to drain the extensive antethoracic cellulitis. The anastomosis on the neck gradually disrupted and the end of the intestine fell away completely. Although the drawn out intestine retained its vitality for a long time, little hope remained, after the acute phlegmonous process had ceased, of placing it in the proper manner under the skin of the chest. After many months of suspense a cutaneous anastomosis was made and the operation was completed by using the combined method.

MOBILIZATION AND TRANSPLANTATION OF THE INTESTINE

The operation is performed under spinal anesthesia, 0.8 to 1.0 cubic centimeter of 1 per cent percaine being injected for adults at the level of the 12th thoracic spine The anesthesia is invariably efficient, reaching the level of the mammillary line and sometimes higher. In the most recent cases, we have infiltrated the subcutaneous cellular tissue with ½ per cent procaine prior to the moment of forming the subcutaneous tunnel. The solution is injected with long 12 centimeter needles upward from the border of the anesthesia to the left side of the neck as far as the mastoid process.

The gastrostomy tube is removed after the liquid has been evacuated with an aspirator. The opening in the abdomen is plugged fairly tightly with conical gauze mesh.

A small laparotomy incision is made 7 to 8 centimeters upward from the umbilicus. There is no need to make an incision of greater length since (1) the subcutaneous tunnel can be easily prepared with the help of a special instrument, and (2) since we have abandoned the final gastroenterostomy there is nothing to be done in the epigastrium itself.

Extreme difficulties arise if the gastrostomy has been performed along the linea alba and not on the left, pararectally. Laparotomy must be performed either by entering below the umbilicus, or the medial gastric fistula must first be moved to the left pararectally before mobilization of the intestine is carried out.

We begin to inspect the mesentery from the upper end 8 to 10 centimeters away from the duodenojejunal flexure. It is not advisable to go lower lest a loss in the length of the mobilized intestine be incurred. On the other hand it is not worth while to ascend any higher for two reasons: (1) because it will be difficult to anastomose the short proximal end into the side of the intestine below the mobilized point, and (2) the advantage gained is insignificant, as it is all at the cost of the intestine and not of its mesentery which at this point narrows and contains the last remnant of radial vessels.

If this area is left at the end of the mobilized sector, almost the whole remnant will be caught in one common ligature—it will be found to contain a large portion of the intestinal tube which curves round the end of the dissected mesentery; the mesentery proper will not become longer and this is the principal requirement.

The secret of success lies in a maximum utilization of the mesentery lengthwise. Not a single ligature of the vessels should involve the serous layers of the mesentery; both sides of the mesentery must be dissected with a knife along the avascular field and with scissors over the areas where the incision of the mesentery layers crosses the radially located vessels. These sections of the mesenteric layers must be made archwise parallel to the central arcades of the mobilized portion, a protective margin of from 1.5 to 2 centimeters in width being left. These adjoining arch-shaped incisions of the mesentery join in front of the large radial vessels which are to be dissected. The trunks must not only be separated out as far as possible, i.e., as near as possible to the root of the mesentery, but besides this all around them the mesenteric cellular tissue with the lacteal and small blood vessels must be cut in portions which require the finest ligatures. It is not until after the large trunks have been separated out cleanly that they are clamped, dissected, and ligated. The stump with the arcades will run inward into the mesentery under the edges of its dissected peritoneal surfaces. The steep vascular arcades will straighten out somewhat, and the free edges of the mesentery will be able to stretch out lengthwise.

Every succeeding arcade and every succeeding large radial trunk is treated in the same way. If sufficient length of mesentery and intestine seems to have been mobilized to reach to the neck the upper end is dissected between two crushing clamps. The duodenal end is left *in situ*, while the intestinal end is immediately closed. It is now time to assess the length, to see if the mobilized mesentery will allow the intestine to extend without any tension as far as the mastoid process. In case the length is inadequate and dissection and ligation of the next arcade and the trunk nourishing it are doubtful, then before proceeding further the gastric clamp with rubber covered tubes should be introduced. Without denuding the vessel and through a small incision in the mesentery along the avascular field, the clamp should be closed to compress the vessel temporarily. In most cases the intestine immediately begins to show stormy peristalsis. It sometimes happens that this is immediately followed by cyanosis of the entire isolated segment of intestine or along one or two arcades of the closed upper end of the intestine. The cyanosis may reach an alarming stage during the first 1.5 to 2 minutes. This should not, however, lead to undue haste in removing the soft clamp. We have on many occasions observed that peristalsis in the intestine continues or the intestine reacts vigorously to tapping and in a short time the entire intestine regains normal color and the vessels of the mobilized mesentery pulsate adequately. The vessel now can be safely dissected and ligated.

Before the tunnel is made an anastomosis of the duodenal end of the intestine with the distal end of the mobilized segment must be made. This short portion lies to the left of the medial line, and therefore an end-to-side anastomosis must be made into the left semicircumference of the distal intestine. The incision in the distal intestine should not be made opposite the line of attachment of the mesentery but vertically, i.e., perpendicular to the long axis, from the middle of the intestinal circumference along the whole left semicircumference as far as the mesentery. Into the gap thus formed in the intestine the end of the duodenal segment is sutured end-to-side. The mesenteries are also sutured together.

After a change of gloves the formation of the subcutaneous tunnel is carried out. For children a long forceps, preferably a curved one, may suffice. For adolescents, or little girls, a large powerful Graser gastric clamp may be sufficient. Pushing these instruments under the skin and separating the branches, the surgeon is able to reach a point in the neck above the clavicle. Should the instrument be not long enough, an attempt is made to bend the patient's head and neck, thus allowing the instrument to penetrate still further and by the separating of the branch of the instrument

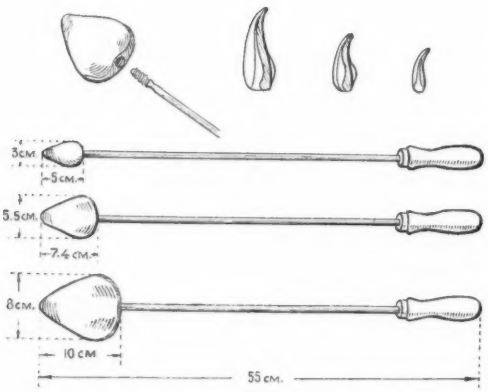

Fig. 11. Author's instruments used in making the subcutaneous tunnel.

the tunnel is completed. With tall patients these instruments are not sufficiently long. In such patients the skin on the neck near the angle of the jaw may be opened with a separate incision, and a tunnel is made to extend in the opposite direction—from above down to meet the first.

In order to obviate opening the skin which would have to be closed again, I have constructed special iron rods tipped with screwed on special heart-shaped and slightly curved ends of 3 sizes (Fig. 11). At the moment when the assistants lift and hold up by means of sharp hooks both skin edges of the upper angle of the laparotomy wound, these rods are pushed into the tunnel, thus easily separating the subcutaneous cellular tissue and by a simple forward movement finishing the whole tunnel as far as the mastoid process. The whole procedure occupies less than 1 minute. A tunnel of uniform size is produced. The hemorrhage under the skin is insignificant and can be stopped by a large pad of dry gauze mesh introduced by means of the same rod.

Into the tunnel a large Graser gastric clamp is introduced, the tips being pushed to the end of the tunnel on the neck. The branches are opened slightly, the skin of the tunnel being raised by the spread-out ends of the instrument in such a way that these ends may easily be felt and even seen through the skin. Then a straight needle with a long thread is introduced into the skin. The end of the needle is clutched under the skin with a clamp, the needle is pushed inward drawing after it the thread which is painted with iodine as it enters the tunnel. Taking out the clamp through the entrance into the tunnel, we extract the needle and grasp the thread which has passed the whole way through the tunnel from above. It remains only to fasten to it the ends of the "tobacco pouch stitch" at the end of the closed intestine and to begin drawing the intestine into the tunnel.

It must be understood that this thread only directs and gently pulls the intestine with the mesentery into the cavity of the tunnel. The entrance to the tunnel is separated widely and, with the use of the fingers, the intestine with the mesentery is inserted, smoothed out, and pushed into the tunnel, with particular care taken not to twist the mesentery along the axis. The procedure is made easier if simultaneously the intestine is gently pressed and massaged through the skin of the tunnel.

In almost every case insertion of the intestine with mesentery is accomplished rapidly and without any difficulty. When the end of the intestine has reached the very end of the tunnel and the stump of the intestine can be palpated there through the skin, the end of the thread drawn out through the puncture is tied over a piece of gauze, and the abdominal wound may be closed (Figs. 12, 13).

In 1 or 2 cases, on the 4th or 5th day after operation a small hematoma or aseptic wound secretion from the whole enormous tunnel was seen to have accumulated at the lower angle of the wound. A suture or two had to be removed from the skin to release the accumulation. On 2 other occasions small portions of the omentum fell out together with the evacuated aseptic hematoma. On rare occasions, for the prevention of such accumulations a drain with an exit through the lower end of the wound can be used for 24 hours.

On several occasions, however, we observed a certain stasis in the artificial esophagus at the level where the intestine passed through the aponeurosis into the abdominal cavity without any other complications having occurred affecting either the wound or the tunnel in the postoperative period. It has rarely

Fig. 12.

Fig. 13.

Figs. 12 and 13. The intestine with mesentery has been inserted, the end of the string tied over a piece of gauze, and the abdominal wound closed.

Fig. 14.

Fig. 14. Successful reconstruction of esophagus in a girl aged 14 years, after numerous unsuccessful attempts had been made to construct an antethoracic esophagus.

happened that stasis of this kind in the reconstructed esophagus reaches such a degree as to necessitate additional surgical measures. Such a state, however, would continue for months or even years and would be clearly manifested not only by x-ray examination with a constant medium but would be visible even to the eye after every food intake. There would result considerable distention of the lower portion of the antethoracic esophagus and intensified peristalsis of the intestinal loops (Fig. 34).

The same defects were repeatedly noted even more plainly in cases in which this condition was not the result of complications of the operation but were inherent in the method itself. These arguments are equally applicable to both the Roux and the Herzen methods as originally performed. In 3 cases the end-to-side anastomosis of the new esophagus with the stomach, after the method of Roux, was performed. Each time the terminal loop hung down on its mesentery below the large curvature regardless of whether the junction had been made with the anterior wall of the stomach or the posterior, i.e. through the mesocolon. The latter loop of the intestine expanded considerably with food intake and periodically, in large peristaltic waves, would evacuate its contents into the stomach through the anastomosis. It seemed almost as though there were two stomachs, a natural and an artificial one formed by the dilated terminal loop of the artificial gullet.

The result was even worse with the Herzen method of anterior anastomosis with the intestine. In each case a vertical anastomosis, i.e., from the lesser to the greater curvature, was made. The opening was sufficiently wide to permit the unhampered passage of consumed food into the stomach; nevertheless it was just at this point that in many cases trouble lurked. The loop lying above the anastomosis, not being in any way attached within the tunnel, evidently descended under the skin below the gastrojejunostomy, thus producing considerable constriction with inevitable stasis following. As a result, the anastomosis not only failed to ensure the passage of food into the stomach but even seriously hampered its passage along the constructed esophagus.

In the Herzen method the anterior gastrojejunostomy might be performed either at the first stage, i.e. transplantation of the intestine, or as the concluding step, for instance, in cases of operative closure of the temporary existing gastrostomy. The enlarged opening

of the latter might be used for the junction with the new esophagus. The idea is logical and even appealing and yet this concluding step proved always to be very complicated and to involve considerable risk. It was no easy task to identify and mobilize, among the numerous adhesions, the tortuous intestinal loop and to draw up from the left the mobilized gastric fistula for anastomosis.

From the point of view of the amount of time and strain, such an operation presented greater difficulties than the construction of the esophagus itself. We have long since come to the conclusion, therefore, either to make such a junction immediately during the first stage of the operation or to omit the anastomosis altogether. At present we are abiding by the latter decision for the following 4 reasons: (1) The anastomosis entails an undesirable additional interference which complicates the first difficult stage of esophageal construction. Interference is all the less desirable since the operation is performed on a level with the very root of the mobilized mesentery, and, at the risk of introducing infection, the junction must be made *in situ* in direct proximity to a huge cellular wound at the entrance to the tunnel. (2) The step is difficult if such junction is made by means of a repeated operation. (3) The anastomosis may be doubtful and, at times, even poorly functioning and thus falls short of its purpose and hampers the passage of food along the constructed esophagus. (4) Finally, the uselessness of such a junction. Experience with dozens of patients who have for many years taken nourishment through the new esophagus, thus excluding the stomach, has convinced me of these facts. We have observed no disturbance in metabolism, in hematopoiesis, or in growth or development in children.

All these factors have influenced me in deciding on the present operation as the one of choice—either the Herzen method, but without gastroenterostomy in cases in which it is possible to transplant the intestine sufficiently high and the pharynx allows direct connection; or the intestinal esophagus with a cutaneous portion added, but without gastroenterostomy.

ANASTOMOSIS OF THE INTESTINE WITH THE PHARYNX

The operation is performed with bilateral paravertebral anesthesia of the cervical plexus. From 20 to 30 cubic centimeters of 1 per cent novocain solution are injected into the zone of the transverse processes of C-III, i.e. along the posterior border of the sternocleidomastoid muscle at the level of the angle of the lower jaw. It is always easy to orient oneself by means of the needle as to the exact bony structure. The novocain injection must be supplemented by anesthetization of the mucosa of the pharynx and of the entrance to the esophagus either by painting with a 5 per cent solution of percaine or by injecting from 5 to 6 minims of this solution into each nostril with the head thrown back.

The cutaneous incision is made along the anterior edge of the sternocleidomastoid muscle away from the peristaltic and easily palpable intestine. The cervical part of the esophagus is exposed in the usual manner, i.e. after the omohyoid muscle is dissected with care to avoid the main vessels medially and not to disturb the cellular tissue covering it.

The upper thyroid artery almost always must be divided. In most cases the lower thyroid artery must also be ligated and sectioned in order to obtain free access to the esophagus. After careful hemostasis the esophagus is easily separated from the friable prevertebral cellular tissue and when the intestine is mobilized from the upper end of the subcutaneous tunnel the anastomosis can be made.

The latter may be performed in three different ways: (1) side-to-side, (2) end-to-side, or (3) the end of the dissected esophagus may be joined to the side of the intestine. We have tried all three ways and have discarded two of them. Anastomosis of the end of the intestine into the side of the esophagus is not difficult to perform by cutting off the invaginated end of the intestine. In this procedure, however, the size of the opening is limited by the transverse dimensions of the intestine. It is clear that in the side-to-side anastomosis the opening can be made considerably wider than the transverse diameter

of the intestine. The idea of an anastomosis of the dissected esophagus into the side or obliquely into the intestine seemed to have possibilities. If the long proximal end of the esophagus could be drawn forward sufficiently, the junction itself could be made after the manner of a Witzel gastric fistula.

As previously stated, we have totally abandoned both types of terminolateral anastomosis, basing our decision on the following facts. In order to attach the proximal end to the intestine the esophagus itself must be cut across. First, this is not as simple as it seems, and second, it gives rise to serious apprehension with regard to the distal end. If in the latter there should exist any filiform fistular passage downward, hermetic suturing of the distal end, despite technical difficulties, may be performed in the hope that the mucous secretion in the stump will drain through the fistular passage into the stomach. If, however, obstruction of the esophagus is complete, closure of the distal end would create an enclosed cavity and there would be the danger of an empyema with possible rupture into the mediastinum or pleura. There remains only the method of attaching the distal end of the esophagus to the lower angle of the wound. This step, of course, would gravely disturb asepsis and would introduce additional risk in the postoperative course. Should everything proceed smoothly and the blind retrosternal end of the esophagus not prove to be too long or spacious, there is still the possibility of attempting later to eliminate this fistula by doing away, in several stages, with the mucous membrane beginning with the bottom of the sac.

It is readily apparent that transplantation of the end of the dissected esophagus is not only a task involving difficulty and risk, but the method has an important constructive drawback. Of 2 cases, 1 ended in late failure and the other in disaster.

CASE REPORTS

A girl, aged 14 years, was admitted to our clinic after numerous unsuccessful attempts had been made to construct an antethoracic esophagus. She had been fed through a gastrostomy for a number of years and when admitted had a countless number of scars on the breast, abdomen, and neck. On the thorax a Bircher skin tube had narrowed in places so that it hardly admitted a fine bougie; in other places it had fallen to pieces, leaving gaps from 2 to 3 centimeters each in breadth. The entire cutaneous plastic tube had to be done away with, the scars excised, and the skin returned to the original sites. After a 3 weeks' interval the intestine was drawn from the abdomen onto the neck. The end of the intestine reached to the mastoid process where it was attached to the skin under a star-shaped scar, marking the point of a former and now completely overgrown esophagostomy.

A week later the second stage of the operation was performed. The proximal end of the esophagus was freed from the profuse scars as far as was possible, so as to implant the esophageal end, with sufficient ease, into the intestine, thereby promptly terminating the constriction.

Complete success was achieved, and the girl was soon afterward transferred to another service for studies on digestion and metabolism. Later food was given by mouth to preserve the gastrostomic fistula for some months to come (Fig. 14).

She returned a year later with almost complete obstruction of the new esophagus where it joined the intestine. It appeared that as swallowing gradually grew more and more difficult, she resorted with greater frequency to her customary manner of feeding, namely, masticating her food in the mouth and then spitting it out into the funnel inserted in the gastric tube.

At operation the junction was found surrounded by numerous scars. The anastomosis was separated and it was found that the caliber of the opening had remained 1 to 1.5 centimeters in diameter. Instead of enlarging the existing junction it seemed best to make two definitive stomas, in the intestine and the esophagus respectively, both large in diameter. A month later the stomas were covered with a cutaneous flap, and the patient left the clinic perfectly able to swallow any kind of food and with the gastric fistula forever closed.

A boy, aged 8 years, who had been taking food through a gastric tube for 5 years, was so emaciated that for 6 weeks he had to be fed with cod liver oil and vitamins. He withstood well transplantation of the intestine onto the neck under spinal anesthesia. In the second stage the fretful child would not allow the anastomosis to be performed under regional anesthesia alone, and so in addition to the cervical block he was given light ether narcosis. The intestine on the neck was in excellent condition, and we succeeded in segregating the cervical part of the esophagus without hemorrhage. Intending to attach the proximal end into the intestine we cut across it between two crushing clamps. The upper part was anastomized successfully with the intestine, and it was decided to attach the distal part to the lower angle of the wound. To achieve this, it was necessary to pull, with a piece of gauze, energetically at the clamp to free the esophagus from the surrounding cellular tissue, with a view to drawing out the esoph-

agus sufficiently to suture it without removing the crushing clamp for some days. And here, during these manipulations a sound, suspiciously resembling aspiration of air in breathing, was heard. The sound seemed to be coming from under the clavicular region, and immediately rupture of the pleura was suspected. It was dangerous to draw out the esophagus any further, and yet the mobilized portion might not suffice for attachment to be made without removing the clamp. The attachment of the esophagus to the angle of the wound was efficiently performed, but it was not possible to forego placing a drain at the entrance into the mediastinum.

On the 2d day the temperature rose precipitately, by evening reaching 40 degrees C. The child's condition was alarming; there was rapid br[illegible] some cyanosis. He died on the 5th day. [illegible]oscopy revealed a purulent empyema of the right pleura caused by a slight rupture at the point where it was closely attached to the esophagus at the site of a completely impassable stricture.

Had side-to-side instead of the terminolateral anastomosis been chosen, the anastomosis would have been performed with greater ease and at much smaller risk.

Terminolateral anastomosis of the intestine with the esophagus is easier to perform because there is no need to dissect the esophagus transversely. We have used this procedure on two occasions when there was a surplus of intestine in the subcutaneous tunnel on the neck. Not only is the size of the junction in such cases limited to the transverse dimensions of the intestine, but the actual direction of the attached intestine, perpendicular to the length of the esophagus and to the normal flow of food, creates conditions scarcely favorable to the passage of swallowed food, from the esophagus into the intestine. It is obvious that the food eaten will pass first almost wholly along the esophagus as far as the stricture and it is only after the blind sac is overfilled that it begins to evacuate its contents into intestine.

There seems to be no way of avoiding such a contingency in the side-to-side anastomosis. However, such an anastomosis can be made larger than if the terminal method is used and also the attached intestine will come to lie parallel to the esophagus along the whole length of the anastomosis. In any case conditions for evacuation will be much more favorable.

Nevertheless the falling of the swallowed food into the blind end of the esophagus is totally unavoidable, a fact which gives rise to two questions: (1) to what extent does the phenomenon disturb the new esophagus, and (2) is it possible to remove this blind sac by any special means?

The first question can be answered from personal experience. Never once have these blind sacs caused our patients any particular annoyances despite the fact that in some cases the sacs were quite large as may be seen by the x-ray pictures (Figs. 15, 16, 17, 18).

The explanation may be that these blind sacs can be regarded in no way as pathological diverticula of the esophagus with destroyed muscular wall and progressive hernial protuberance of the mucous sac. Above the strictures in most cases our patients have an esophagus that is not only sound but that even has a somewhat thickened muscular wall due to hypertrophy.

It may be that such hypertrophy may partly persist even after evacuation of contents of the esophagus into the intestine, in so far as the blind sac is compelled uninterruptedly to free itself by the eructation upward of food masses that have passed into it toward the opening of the anastomosis. Our observations over a number of years lead to the conclusion that these blind sacs show no tendency to extend either in length or in diameter, nor have we ever observed ulceration caused by retention of food.

As to the second question—the possibility of eliminating the blind esophageal sac below the anastomosis—our arguments are purely theoretical, since neither with curettes nor electrolysis have we ventured to perform demucosation in our patients. The same applies to the burning of the mucous membrane with chemicals, such as chromic or carbolic acid, through the esophagoscope. The burning would seem to be practicable and, if it is begun from the bottom of the blind sac and is carried out in several stages, a complete obliteration might be attained. The procedure requires experimental confirmation in order to determine the requisite concentration of the caustic solutions and to determine how extensive an area can be burned at each successive step. We have so far never had occasion for such subsequent manipulations as the

Fig. 15.

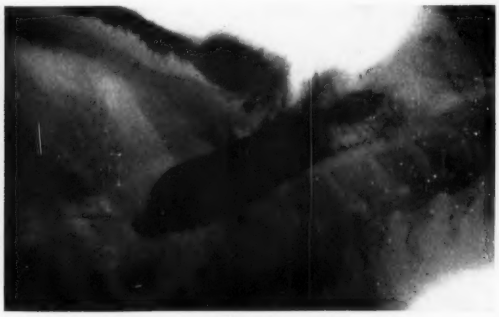

Fig. 16.

Fig. 17.

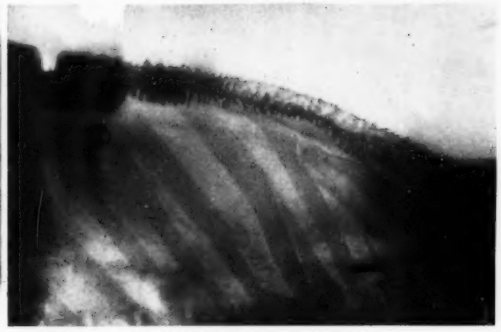

Fig. 18.

Figs. 15, 16, 17, and 18. Blind sacs in esophaguses.

strictures were never below the arch of the aorta and the remaining blind sacs were consequently not overlarge. Should need arise, efforts might be made to achieve obliteration of the esophageal sac even after construction of the intestinal esophagus. Introduction of the esophagoscope should not be particularly difficult as we have twice had occasion to discover in other patients in extracting large plum stones that had caused choking.

CONSTRUCTION OF PHARYNGEAL STOMA

Construction of the pharyngeal stoma is one of the most difficult tasks in the reconstruction of the esophagus. We have to deal with cases in which it seems impossible to make a direct junction of the pharynx with the drawn-up intestine, and in which the high level of the stricture make the possibility of building a new esophagus questionable. Besides complete obliteration of the esophagus, the patients have had severe burns of the laryngeal orifice and were in danger every moment of dying of asphyxia.

In 4 cases when the patients were admitted to the hospital they had already had a tracheotomy. Moreover, in 2 other of our patients the question of an urgent tracheotomy arose during the construction of the esophagus. One patient had been on the point of being placed on the operating table for tracheotomy 6 times during the period when the unfortunate girl was being fed through a jejunostomy. After consultation with an eminent laryngologist it was declared that there was no hope of restoring breathing otherwise than by means of tracheotomy. Even less were the chances of building a definitive pharyngeal stoma as the pharynx had become merely a short narrow funnel inside of which the epiglottis was bound by solid scars along almost the entire surface of the posterior wall. Despite the unfortunate conditions it was decided to operate. Cervical anesthesia was

Fig. 19. Postoperative photograph of patient in excellent health after severe burn of the esophagus and pharynx.

used and the esophagus was found to be a solid shaft. The lateral wall of the pharynx was intact and showed elasticity both above and below the hyoid bone. Subperiosteally the entire left half of this bone was removed and the lateral pharyngeal wall could then be isolated. The pharynx was opened and with scissors the incision was continued downward as far as the stricture and upward almost up to the root of the tongue. The mucous membrane and entrance of the larynx were promptly painted with a 10 per cent solution of cocaine. We immediately succeeded in attaching the anterior edge of the incision to the skin by means of several sutures. The posterior edge, however, could not be drawn out because of the adherent epiglottis. With a scalpel the epiglottis was separated from the mass of scar tissue, and we were able to draw out and suture the freed lateral posterior wall of the pharynx to the posterior edge of the skin incision. The pharyngostomy was fairly extensive, but out of this large opening the epiglottis protruded in a transverse direction to at least a half of its length. It was feared that very soon grave mechanical disturbances in breathing might ensue, that the ability to speak would be greatly hampered, and that even the new esophagus itself would prove to be worthless because food swallowed, especially liquids, might find its way into the respiratory tract. All these fears fortunately failed to materialize. The postoperative period was smooth and the patient immediately began to breath quite freely. In 2 days the epiglottis protruded less from the pharyngeal stoma and began to assume a more oblique position; a week later it had become entirely concealed in the depths of the stoma and lay vertically. The intestinal esophagus was a real success; no trouble was experienced with the voice and food did not enter the respiratory tract.

Another patient, who also had a stricture high in the pharynx and scar tissue causing stricture of the laryngeal orifice, without any ostensible reason, began to suffer periodically from asphyxia. The question of performing a tracheotomy of urgency had repeatedly arisen but the patient refused to undergo this operation. The choking paroxysms occurred at intervals of several days and passed without help within a period of 2 or 3 hours. Her general condition was so much improved by feeding through a gastric fistula, and she began to gain so much in weight that it was deemed advisable no longer to delay the transplantation of the intestine lest additional difficulties should arise when the work on the fattened mesentery was begun. The intestine was drawn high up on the neck; the operation being admirably borne by the patient, but the attacks of asphyxia recurred. She was then transferred to a special otolaryngeal clinic with the request to undertake treatment of larynx. She remained there for over a month and was sent back. A reconstruction operation at the entrance of the larynx was thought by specialists to be impossible and the patient repeatedly refused to submit to tracheotomy. One morning she was found dead in her bed; she had been asphyxiated during one of her attacks.

In another patient a burn of the pharynx precluded every hope of making a stoma for the reconstruction of the gullet, and at the same time the narrowing of the orifice of the larynx by scars was so great that removal of the tracheotomy tube was out of question. Operation was begun with the cervical stage so as to avoid intestinal transplantation

Fig. 20. Fig. 21. Fig. 22.

Figs. 20, 21, and 22. Various stages in patient who finally despite loss of most of the pharyngeal muscles could swallow food efficiently and had no difficulty with the reconstructed esophagus.

in case of failure of the pharyngeal stoma. Fortunately, partial success was achieved at once in that although the stoma narrowed to such an extent that passage through the tube could be maintained only by means of a permanent rubber drain, on the other hand the freeing of the epiglottis of scar tissue produced considerable improvement in breathing. Improvement continued and at intervals the patient began to do without the tracheotomy tube. By the time the new esophagus was constructed, breathing was good enough to permit removal of the tube. The intestinal plastic operation was successful at once. However, it required 3 additional operations before the pharyngeal stoma finally allowed the passage of every kind of food without hindrance. This patient has remained in the best of health and has an excellent artificial esophagus (Fig. 19).

These cases illustrate the great difficulties encountered in these patients both because of the high level of the burn in the pharynx, and because the strictures hamper the respiratory tract. Moreover, irrespective of the circumstance burns situated high in the esophagus produce conditions most difficult to overcome in building a reliable pharyngeal stoma which has some assurance against subsequent narrowing. Just as with the purely cutaneous method, gastric stomas also have the same tendency to become narrow. The stoma begins to narrow almost immediately and often within 4 or 5 weeks an opening that would at first easily allow 2 fingers to be inserted in its mouth, will have grown over entirely so that not even the finest probe will pass.

By the subperiosteal removal of one-half of the hyoid bone, the drawing up and outward of the pharyngeal wall is greatly facilitated and the tension on the sutures between the edges of the mobilized pharynx and the skin is considerably lessened. It is necessary to mobilize to a larger extent the edges of the skin; the skin that has been loosened should descend freely into the operative wound to meet the edges of the mobilized pharynx. Since these measures were devised we have used them in every case.

It should be emphasized that the main part of the operation consists in mobilizing the remnants of the pharynx. To obtain sufficient access to it many sacrifices have to be made: the upper thyroid artery must be ligated, and the lingual artery has to be out; the salivary glands, both the sublingual and submaxillary, have to be removed, and this involves dissection of the external maxillary artery. But these sacrifices are not great ones, and neither is the dissection of the digastric and stylohyoid muscles. It is essential that the large marginal branch of the facial nerve be spared, and they can easily be spared if care is used. The hypoglossal, particularly, and lingual nerves present greater difficulties.

The extent to which the pharynx is mobilized should by no means be minimized in the hope of attaining success at a cheaper price. Should mobilization prove insufficient, then,

Fig. 23.

Fig. 24.

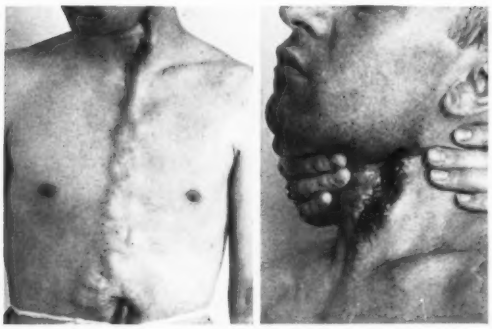

Fig. 25.

Figs. 23, 24, and 25. Patients showing adherence of two openings and position in depths of neck stoma.

no matter how the edges of the skin have been separated in order to approximate the pharynx, the tension of the sutures will cause the edges of the mucous membrane to separate and to recede inward. The procedure will end not only in a marked narrowing of the stoma which will demand repeated operations, but as frequently happens such a stoma becomes completely grown over and the surface of the wound closes.

Repeated operations of this nature always prove to be far more difficult than is the primary procedure because of the presence of vascular scar tissue, the difficulty of administering anesthetics, and the distortion of the organs of the neck making dissection difficult and the danger of injury imminent.

The possibility of injury to nerves has already been mentioned. The lingual artery was twice injured in attempts to dissect it free from scar tissue. The proximity of large vessels, especially the jugular vein, prevented the clamping of the bleeding vessel too tightly while the degree of hemorrhage suggested injury of a larger vessel. In one case it was necessary to tamponade the wound, and we were not able to make an opening into the pharyngeal cavity. Another patient had an excellent intestinal stoma high on the neck, and after great difficulty an opening was made into the oral cavity. We were unable to rely upon the possibility of mobilizing both edges of the concealed pharynx so we were content to attach only the forward edge to the loosened cutaneous flap. Through the opening thus obtained a piece of a rubber gastric tube was introduced, passed sideways near the root of the tongue, and drawn outward from the mouth. Both ends of the drain were joined together, thus forming a rubber ring threaded through the mouth onto the neck. The patient stoically endured the discomfort for a fortnight until the wound had granulated and partly epithelized. By means of a set of short, wooden, cone-shaped dilators to replace the rubber drains, within a few days, the fistula had been enlarged to great dimensions. Each time after maximum distention was reached, the patient herself personally controlling the pressure of the dilators by the sensation of pain, the dilator was fastened around the head by a gauze string and was left in place for several days without being removed. A month later patient could bear a dilator of from 3 to 3.5 centimeters in diameter (Figs. 20, 21, 22). An enormous opening through which the root of the tongue could be seen was thus produced. Then, callous scars beneath the cutaneous edges of this opening were removed and the widely mobilized edges of the skin and mucous membrane of the mouth were drawn up without tension. In four stages, at intervals of a fortnight, the callous scars around the edges were excised completely and the mobilized skin was sutured securely to the mucous membrane of the mouth and remnants of the pharynx.

It is interesting to note that this patient, like a number of other patients who had practically no pharyngeal muscles remaining, swallowed her food efficiently and had no difficulty whatsoever in using the artificial esophagus. All food, liquid as well as solid, passed rhythmically from the mouth due to

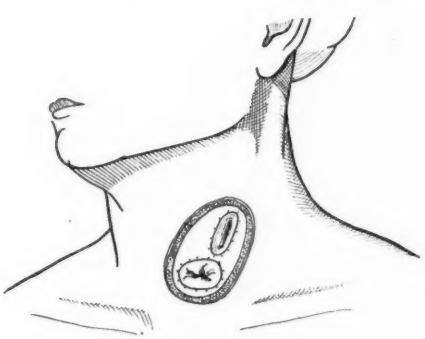

Fig. 26.

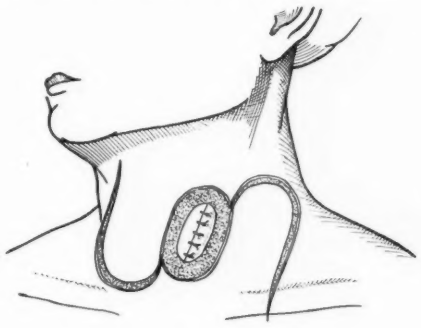

Fig. 27.

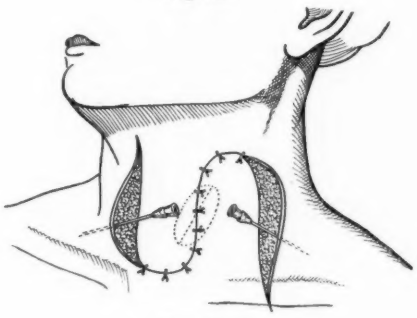

Fig. 28.

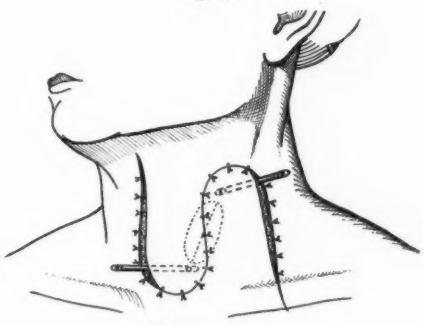

Fig. 29.

Figs. 26, 27, 28, and 29. Various steps in the use of two lateral flaps drawn together diagonally to correct the defect in the neck.

the action of the muscles of cheeks and tongue.

ANASTOMOSIS OF THE PHARYNGEAL AND THE INTESTINAL STOMAS

It is sometimes possible to make a partial anastomosis of the pharyngeal and intestinal openings as early as the second stage, that is while the actual pharyngeal stoma is being shaped. Sometimes it happens that the segregated remnant of the esophagus does not suffice for complete anastomosis with the segment of intestine now lying in the subcutaneous tunnel.

But usually there are sufficient segments of the esophageal wall or pharynx to make an efficient anastomosis between the lateral edge of the opened esophagus and the medial border of the opening in the intestine. Therefore, we content ourselves with anastomosis of these two organs by one layer of sutures and attach the free edges to the edges of the skin. As a result the two openings come to adhere, lying in the depths of an excellent general neck stoma. It is thus possible to close the esophagus by means of a small oval or round flap so that the site of the anastomosis is covered by shifting on to it the two lateral oval flaps (Figs. 23, 24, 25).

When the stricture is located high in the neck and unavoidable dilatations and plastic correction operations on the pharyngeal opening are in prospect, the intestinal stoma should be formed at some distance to preserve space for any necessary operative corrections of the pharyngeal stoma. In such cases the stoma will be divided by a cutaneous belt 1.5 to 2 centimeters wide. In the plastic closure the cutaneous form will not be round, but oval, along the line of the neck.

It is always easy to conceal the defect on the neck by drawing together the widely sep-

Fig. 30.

Fig. 31.

Fig. 32.

Fig. 33.

Fig. 34.

Fig. 35.

Figs. 30, 31, 32, 33, and 34. Patients after plastic operation with two lateral flaps drawn diagonally together to correct defect in neck.

Fig. 35. Patient in whom a tubed pedicle flap from the arm was utilized to close the defect in the neck following anastomosis.

arated skin edges. There is always sufficient skin on the neck for this purpose. This step, however, should not be undertaken because the line of the sunken sutures closing up the inner wall of the new esophagus coincides in its entire length with the line of sutures which draw together the outer edges of the skin. An inner suture may easily wear through or necrosis may occur in a small section of the skin that was separated for the sinking and suturing of the two stomas. In so far as this point coincides with the unhealed line of sutures on the exterior skin, a straight open fistula may form which shows absolutely no tendency to heal. This fistula will assume shape and narrow down but will not heal and will have to be closed by operative measures. To avoid this unpleasant contingency we have made it a rule to use two lateral flaps drawn together diagonally. After these are sutured together the inner sunken sutures are crossed only in a single place by the line of outer sutures. This gives a much greater guarantee of success (Figs. 26, 27, 28, 29), but it demands the observance of two conditions. First, the free edges of both flaps must not be sutured

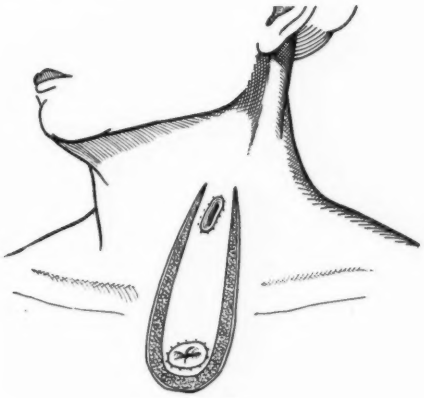

Fig. 36.

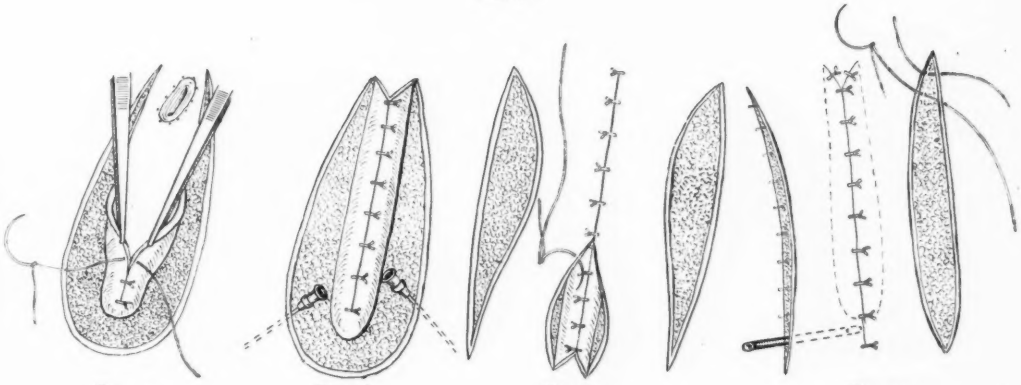

Fig. 37. Fig. 38. Fig. 39. Fig. 40.

Figs. 36 to 40. Steps in the procedure of closing the lower end of cutaneous tube.

to anything. However tempting it might seem to close the defects formed in the places of the flaps, such a procedure is admissible only provided the mobilized new sectors of the skin be attached to fascia, to muscles, and not to the displaced oval flaps. These oval flaps must lie in position without being stretched in the slightest degree with their own weight resting on the surface they are covering. Second, since under these conditions the flaps very rapidly grow into the new soil throughout their entire surface, there arises the same danger as is seen in the linear coincidence of the interior and exterior sutures, namely: the partial necrosis or the cutting through of the interior sutures will lead to the flaps peeling away and to the formation of a straight open fistula. To avoid such a contingency, a fine rubber drain should be placed beneath the base of each flap; the ends of these drains should be just short of the line of the interior sutures, and their outer ends should be fastened to the skin. These drains must be kept in place for 7 to 10 days (Figs. 30, 31, 32, 33, 34).

CONSTRUCTION OF A CUTANEOUS SUPPLEMENT FOR THE COMBINED METHOD OF ESOPHAGOPLASTY

If the intestine has not been drawn up to the level of the pharyngeal stoma, or if it has proved necessary to resect the intestine because of partial necrosis of its end, the upper portion of the esophagus must be constructed

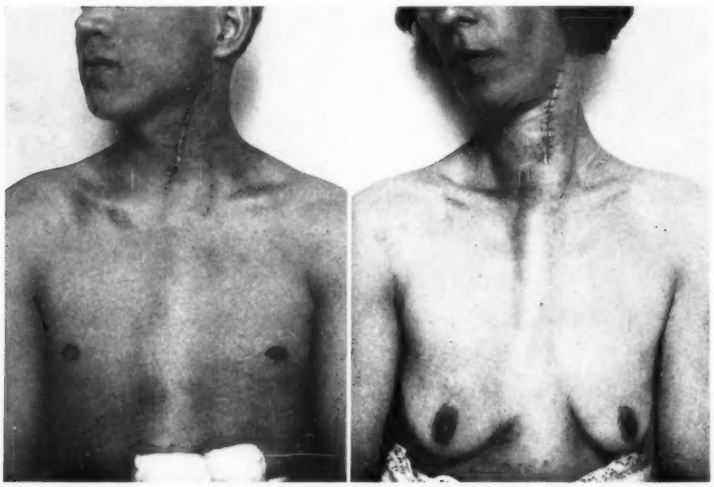

Fig. 41, left. One stage anastomosis between intestinal transplant and pharynx.
Fig. 42. Two stage anastomosis between intestinal transplant and pharynx.

from skin. Two methods are possible, depending upon the length of the remaining gap: (1) when the intestine is drawn up beyond the clavicle or is nearly on a level with it, or (2) when the intestine reaches only to the mammillary line of falls even below it.

In the first instance, an intestinal stoma must first be shaped by suturing the end of the opened intestine into a transverse oval incision of the skin no less than 3 to 5 centimeters wide. After an interval of at least 2 weeks, one may start closing the lower end of the cutaneous tube, stretching it beyond the pharyngeal stoma but leaving the upper end open, gradually narrowing down the size of the cutaneous tube above the level of the pharyngeal stoma in such a way as to make the opening of the upper, open end of the cutaneous tube from 1.5 to 2 centimeters wide (Figs. 36 to 40).

By closing the lower end of the cutaneous tube a certain degree of risk of infecting it is incurred; closing the upper end doubles the risk. Leaving the upper end open is sufficient insurance against any trouble connected with twisting-in the cutaneous welt edging the upper semicircumference of the pharyngeal stoma if we try simultaneously to close the latter.

In the second type, i.e. with a very long cutaneous tube, nothing should be risked even at the lower end. Bircher's procedure should be followed from the intestinal stoma upward onto the neck, passing above the pharyngeal stoma; but both ends of the cutaneous tube must remain open. The upper end should be closed up at the last moment and the lower end of the cutaneous tube must be joined with the intestinal stoma in exactly the same manner as is an oval flap.

RESULTS

Six patients operated upon by the Bircher method (cutaneous esophagus) have had good functional results. One patient died in an interval between the operative procedures. In 2 patients, a peptic ulcer developed in the skin of the new esophagus, and both resulted fatally later on.

Sixteen patients have had a direct anastomosis made between the pharynx and the intestinal transplant. Eleven cases terminated favorably. One 8 year old child died during the operation, and in 4 cases there were various degrees of failure.

Fifty-eight patients have been operated upon by combined methods with 2 deaths during the course of the procedures.

There have been failures demanding alterations and subsequent corrections; the repeated and at times exhausting plastic operations on

the pharyngeal stoma have already been mentioned. It was often necessary to trim the edges of the intestinal stoma. On 5 or 6 occasions open fistulas were formed in the cutaneous tube but all were successfully closed with a Filatov's pedicle graft.

The fate of the transplanted intestine is of much greater interest. In 1 case there was a failure in a one stage total esophagoplasty due to an infection of the tunnel. In 3 cases the reverse situation existed; i.e. there was infection of the tunnel due to partial necrosis of the intestine. In 2 cases of this type, during an uneventful postoperative period with excellent peristalsis along the whole transplanted intestine, on the 5th to 7th day there appeared a well marked and sharply limited discoloration of the skin along the upper end of the tunnel. The temperature did not rise and the patient's general condition remained excellent. The flush increased in intensity, the skin in that sector became glossy, and incisions had to be made. An apparent necrosis of the end of the intestine was taking place. The intestine was resected and the end was sutured to the skin of the chest. The operation had to be finished after a long interval with the aid of a cutaneous supplement corresponding in length to the necrosed intestine. In the third case of necrosis in a transplanted intestine, redness appeared on the 12th day after the operation without a rise of temperature. Only the day before excellent subcutaneous peristalsis of the intestine had been observed. Unfortunately, in this case the necrosis of the intestine took place along a considerable portion of its length, and it had to be removed to a level immediately above the xiphoid.

Without doubt in all 3 cases secondary disturbances of the blood circulation developed but somewhat late, as the result of stasis and gradual thrombosis of the veins in the terminal arcades. To foresee and foretell this is, in my opinion, impossible; however, such a contingency is of rare occurrence. These 3 cases of partial necrosis of the transplanted intestine occurred in a total of 73 cases.

EDITOR'S NOTE: In July, 1943, Dr. Yudin had completed 88 artificial esophaguses; of these 21 were total intestinal esophagoplasties. The direct operative mortality was 2 out of 88 completed cases.

On July 16, members of the Anglo-American Surgical Mission witnessed completion of the second stage of the operation in Case 89; i.e. the direct anastomosis of the intestine with the pharynx and the first stage in Cases 90, 91, and 92, in all of which the intestine was isolated, transplanted beneath the skin of the thoracic wall, and anchored high in the neck.

CORTICAL KIDNEY TUMOR—ANALYSIS OF 100 CONSECUTIVE CASES

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MALIGNANT parenchymal neoplasms of the kidney offer the least favorable prognosis among the tumors of the urinary tract. It is the consensus that surgery is the only hope of cure and no other method of treatment has been found as yet by which the immediate or remote results could be improved materially.

The prognosis in each case is directly dependent upon the degree of malignancy of the growth and upon an early diagnosis. Unfortunately, lack of characteristic symptoms during the early stages of the disease prevents early recognition of the lesion in a great number of cases. Many patients are seen late in the disease, and complete removal of the tumor is impossible because the tumor has spread beyond the kidney or distant metastases have developed. However, even in patients with operable or apparently early lesions, the end-results are not encouraging since local recurrences or metastatic spread may occur a few months or many years following nephrectomy. Furthermore, the prognosis is made worse by the comparatively high postoperative mortality rate which, according to a review of published statistics by Mathé, is as high as 19 per cent.

It is obvious, therefore, that the majority of the reports dealing with the ultimate results accomplished in the treatment of parenchymal kidney tumors presents a gloomy picture. Smith and Young, in a recent analysis of 97 consecutive cases of malignant kidney tumors, found that "most of the patients" died of local recurrences or metastases within 5 years after admission. Those patients who survived the 5 year period died of the disease a few years later. The 5 year survival rate as reported by other authors (Austin, Mathé, Dougherty) varies between 15 and 33 per cent of the cases with operable tumors. The most encouraging results have been published by the Mayo Clinic (Braasch, Judd, Priestley). The latest report from this clinic (Priestley) is based upon 642 patients with various types of kidney tumors. Nephrectomy was carried out in 568 cases (88.5%) and in the remaining 74 cases an exploratory operation revealed an inoperable lesion. Of the 568 patients who underwent nephrectomy 395 had cortical epithelial tumors. Forty-seven and seven-tenths per cent of them survived 3 years; 38.4 per cent 5 years, and 27.3 per cent 10 years or more. No other clinic has been able to accomplish approximately as favorable results but it may be assumed that the percentage of operable patients admitted to the Mayo Clinic is higher than would be encountered at other clinics. In contrast, the percentage of operable cases can be expected to be particularly low in cancer clinics, because patients are frequently referred to these institutions with far advanced or recurrent disease. This statement is borne out by the following figures:

During the past 20 years, 100 patients with malignant cortical tumors of the kidney were admitted to the urological service of the New York State Institute for the Study of Malignant Diseases. Metastases or evidence of local recurrence at the time of admission were demonstrable in 53 of these cases; 23 of them underwent nephrectomy or exploratory operation elsewhere prior to admission. Twenty-four other patients were unsuitable for surgery because they had fixed and extensive tumor masses. Of the remaining 27 patients 11 were referred for postoperative irradiation, 9 had moderately advanced but still operable lesions, and only 3 patients were seen in the early stages of the disease. These figures contrast sharply with those presented by Priestley. Only 27 per cent of our series had a chance to be relieved as compared to 88.5 per cent of the patients admitted to the Mayo Clinic.

From the New York State Institute for the Study of Malignant Diseases.

It is obvious, therefore, that an analysis of our results presents a gloomy picture. It is not so much the object of this study to report end-results, rather it is intended to analyze our material as to history, symptoms, and clinical course.

SEX AND AGE

Among our series of 100 patients there were 65 males and 35 females. The more common occurrence of adult cell type parenchymal kidney tumors in males as observed in our series of patients is analogous with the sex incidence given in other statistics (Israel, Hale and Burkland, Smith and Young, Priestley, etc.). The age of our patients varied from 17 to 75 years with 89 between 40 and 69 years (86 per cent between 40 and 70 years—Israel).

SITUATION AND PATHOLOGY

Sixty-one of the tumors originated in the right kidney and only 39 in the left kidney. Preponderant occurrence of kidney tumors in the right side has been found also by Hale and Burkland who reported that 32, or 59.3 per cent of 54 patients with kidney tumors were situated in the right side as compared to 22, or 40.7 per cent, in the left side. Analogous statements were made by Israel and Kuester. However, these figures are not in agreement with Young's observations. In a series of 41 patients in whom the side involved was recorded, Young found that the tumor originated in the left kidney in 22 cases and in the right kidney in 19 cases.

The high percentage of patients with inoperable or metastasizing tumors in our series of cases accounts for the fact that sections for microscopic examination were available in only 45 cases. The sections were studied in co-operation with our pathological department and the following types of tumors were identified: hypernephroma, 16; papillary adenocarcinoma, 24; carcinoma, 4; sarcoma, 1. In the remaining 55 patients the diagnosis of kidney tumor was based on the patient's history and on various findings such as palpable tumor masses and complete urological examination including retrograde pyelograms.

It is of interest that 4 of our 100 patients showed evidence of double primary malignant neoplasm. One patient had been treated previously for adenocarcinoma of the fundus uteri, another patient had an epithelioma of the larynx coincident with a papillary adenocarcinoma of the kidney, a third patient had a carcinoma of the breast in addition to a hypernephroma, and the fourth patient had a papillary adenocarcinoma of the kidney parenchyma associated with a papillary carcinoma of the kidney pelvis of the same kidney which had metastasized to the bladder.

Although isolated reports on the occurrence of cancers originating simultaneously in a kidney and in another organ or in the same kidney have been reported in the literature (Weisel, Mathé, et al.), it appears probable that multiple primary malignant neoplasms in cases of kidney tumors are of more frequent occurrence than commonly believed. Hale and Burkland, who based their studies on 54 postmortem examinations of patients with cortical kidney tumors discovered two separate primary malignant neoplasms in 9 instances. While such a high occurrence may be incidental, it can be assumed that the number of such cases will increase with further progress in diagnosis and treatment, because many patients, who are being apparently cured from one tumor may live long enough to develop another primary tumor in a different organ.

SYMPTOMS

It has been well impressed on the medical profession that pain, hematuria, and tumor are the cardinal symptoms of a renal tumor. It must be kept in mind, however, that this classic triad of symptoms is encountered as a rule in far advanced cases only. The presence of pain, hematuria, and tumor assured the diagnosis of kidney tumor before the days of pyelographic studies, but, since it represents a late manifestation of the disease, it should be valued rather as a prognostic, than as a diagnostic sign. Pain, hematuria, and tumor were present in 31 of our 100 patients. All of them had far advanced and inoperable lesions. This experience is in agreement with a statement by Smith and Young who found that all their 19 patients, in whom the triad of symptoms was present, were inoperable.

An analysis of the histories obtained in our series of 100 patients revealed that hematuria

alone (15 cases) or in combination with pain (6 cases) or tumor and pain (31 cases) was present in 52 patients. The most favorable prognosis as to possibility of cure was offered by the group of 15 patients with painless hematuria only. Pain (6 cases) or tumor (10 cases) or both (5 cases) without hematuria were present in 21 patients. The remaining 27 patients had no symptoms referable to genitourinary tract prior to time of admission.

In the latter group of 27 cases there was 1 patient in whom the presence of a kidney tumor was discovered incidentally at autopsy following death as a result of carcinoma of the larynx. In the remaining 26 patients the tumor was found when routine pyelograms were made while searching for a primary neoplasm Seventeen of these 26 patients had pain from metastases to bones or various organs, 2 patients complained of intermittent vague pain in the abdomen, and 7 patients had no other symptoms but malaise and loss of weight. It has been stated by Smith and Young that patients with weakness and loss of weight as the initial manifestations of the disease have almost always far advanced and often metastatic lesions when first seen. Our experiences have been analogous. All of our 7 patients of this group had inoperable lesions and died of the disease within 1 year after admission.

The duration of symptoms in 99 of our patients who had various complaints due to the disease, varied from 1 week to 35 years. The diagnosis was established in 57 cases within the first year after the onset of initial symptoms. In 13 cases the tumor was recognized between 1 and 2 years after onset, in 6 patients between 2 and 3 years, and in 15 between 3 and 5 years. In the remaining 8 patients manifestations of the disease had been existent from 7 to 8 years in 3 and for 13, 14, 15, 17, and 35 years in 1 patient each.

The occurrence of cortical kidney tumors of unusually long duration has been mentioned by various authors who based their reports on a large clinical material (Israel and Israel, Smith and Young, Cahill and Melicow, Geschickter and Copeland). Recent case reports by Carlsen and Ockerblad, Grant, Smyth, and others, emphasize that some of these tumors may exist for many years without interfering seriously with the patients' well-being. The fact that 8 per cent of our patients presented a history of from 7 to 35 years' duration suggests that such cases are of more frequent occurrence than the literature would indicate. Although the long existence of these neoplasms cannot be proved, it may be assumed that the history given by these patients is fairly accurate (Carlson and Ockerblad). This view is supported also by Cahill and Melicow, who pointed out that the initial manifestations of the disease may frequently be present even longer than the history suggests.

The occurrence of these cases indicates that there is a certain number of cortical tumors of the kidney which, in spite of definite histological evidence of malignant new-growth, show very slow progress of the disease. These tumors have little tendency to perforate the kidney capsule and, as will be discussed later, if metastases develop, even the metastases have little tendency to progression. Some of these tumors may not affect the well-being of the patients for many years because they exert little toxic effects. They may be discovered incidentally while they are progressing unnoticed or almost unnoticed by the patient or they may be discovered after an acute incident as acute pain or massive hemorrhage. The following case serves as an illustration.

Mrs. A. B., aged 59 years, white female, case No. 48081, was admitted to our service on May 26, 1943. She stated that she was conscious of a tumor mass in the left upper abdomen for a period of 35 years. The tumor had not impaired her well-being and she noticed no appreciable increase in the size of the growth until 3 months prior to admission at which time she observed a sudden enlargement of the tumor. The patient denied any symptoms referrable to the genitourinary tract, particularly hematuria.

She was a fairly well nourished patient who did not look acutely ill. Palpation of the abdomen revealed a slightly movable, smooth, fluctuating tumor mass which occupied the entire left abdomen and extended well beyond the midline to the right side. The urine contained 1+ albumin and scattered white blood cells. The patient's hemoglobin was 85 per cent with 4,400,000 red blood cells. The white blood count showed nothing remarkable aside from a moderate shift to the left. Cystoscopic examination revealed a normal bladder and indigocarmine was eliminated from the left kidney in fair concentration although somewhat delayed. Pyelograms were characteristic

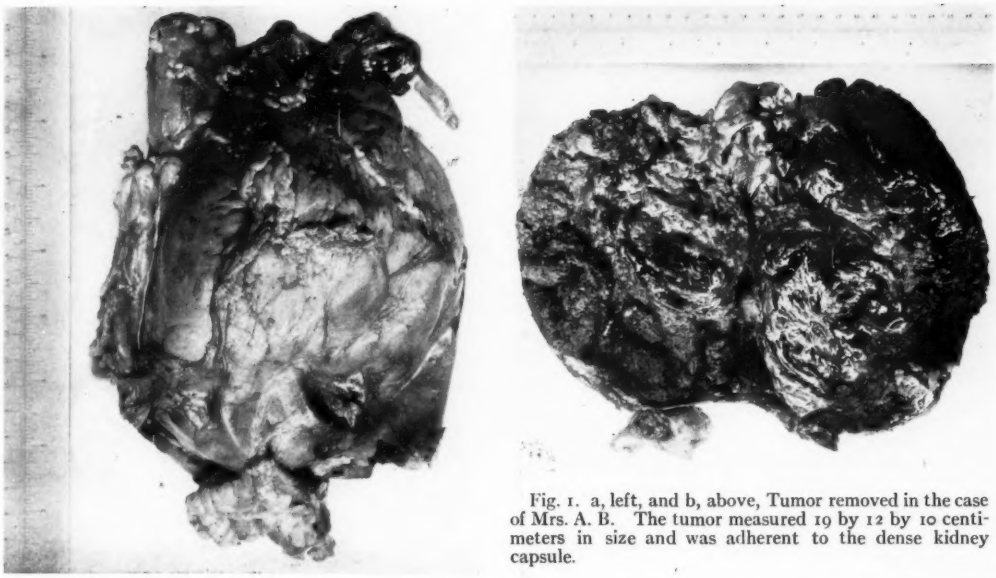

Fig. 1. a, left, and b, above, Tumor removed in the case of Mrs. A. B. The tumor measured 19 by 12 by 10 centimeters in size and was adherent to the dense kidney capsule.

of a large kidney tumor involving the lower pole and the middle part of the left kidney. No distant metastases were demonstrable, and removal of the tumor was carried out through transperitoneal approach on June 3, 1943. Since the tumor had invaded one loop of the small inestines, resection of the bowel loop involved was necessary. The patient was discharged from the hospital on July 8, 1943, after a stormy recovery.

The tumor removed measured 19 by 12 by 10 centimeters in size. On section it was found that the interior of the growth consisted largely of a partially organized blood clot which was surrounded by a thin layer of tumor tissue which was adherent to the dense kidney capsule. A small part of normal kidney parenchyma was present in the region of the upper pole of the kidney (Fig. 1a and 1b). Microscopic examination revealed an adenocarcinoma of adult cell type. A section of the portion of the tumor attached to the bowel showed invasion of the serosa.

METASTASES

Metastatic spread of the disease was demonstrable in 60 of our 100 patients. The organs involved in order of frequency were: lungs, 29; bones, 20; liver, 8; distant lymph nodes, 7; mediastinum, 6; vagina, 4; skin, 3; adrenals, spleen, cervix uteri and urethra, 1 each. Twenty-nine of these patients had multiple metastases with 4 of them having carcinosis. Single metastatic lesions were found in 31 patients. In the remaining 40 cases no evidence of metastases was demonstrable in 28 patients and in 12 patients the records were not sufficiently complete to exclude the possibility of metastases.

It is well known that metastases from parenchymal renal tumors are of frequent occurrence. This is largely due to the fact that kidney tumors have the tendency to invade the renal vein even in the early stages of the disease. Such tumor thrombi have been demonstrable in 54 per cent of 509 patients with hypernephroma at the Mayo Clinic (McDonald).

Numerous instances are on record in which symptoms from metastatic lesions were the first indication of the presence of the tumor while manifestations referable to the primary tumor were totally absent. Study of our material revealed that this was the case in 17 per cent of our patients. The fact that 10 of these 17 patients had initial symptoms due to bony metastases suggests that, in spite of the absence of symptoms pointing to the possible presence of a kidney tumor, a complete urological examination should be carried out in all patients with obviously metastatic bone lesions of unknown primary origin.

a

c

b

d

e

Fig. 2. a, Roentgenogram, case of Mrs. S. R. showing bone destruction superior and inferior ramus of pubic bone; b, filling defect in region of inferior calyx, right kidney; c, irregularity of borders and rarefaction with evidence of new bone formation; d, roentgenogram 4 months later revealed slight progression of primary lesion and new area of bone destruction in region of right pubic bone; e, 7 months later, roentgenogram showed extensive area of bone rarefaction involving superior and inferior ramus of pubic bone extending down to ischium.

As to the incidence of metastases it has been emphasized by Hand and Broders that metastatic lesions are more likely to develop in patients with tumors of grade 3 and 4 malignancy. Similar views have been expressed recently by István. Although this conclusion is in agreement with our present conception of malignant tumors, which is, that tendency to formation of metastases represents an indication of high grade malignant tumor, it must be borne in mind that some of these tumors may exhibit little tendency to further progression for many years although metastatic spread of the disease has taken place. We are referring to those patients in whom not only the primary but also the metastatic tumor may remain in a state of dormancy for many years without receiving any treatment. The fact that these tumors may persist for years without showing noticeable signs of progression can be interpreted as evidence of clinically low grade malignant new growth although such a tumor may have all the histological characteristics of a highly malignant growth.

Cases of this kind have been reported by Lehmann, Smyth, and others. Lehmann's patient had a pulsating metastatic tumor of the skull from a primary hypernephroma of the kidney which persisted for 12 years without impairing the patient's well-being. Smyth removed a tumor from the cerebellum which proved to be a metastatic hypernephroma. His patient underwent successful nephrectomy after recovering from the first operation and remained alive without evidence of the disease at the time when the case was reported.

The following case was observed in our series of patients:

Mrs. S. R., aged 57 years, white female, case No. 30802, was admitted to the hospital on December 1, 1937. She gave a history of having gradually increasing dull pain in the region of the right groin of 1 year's duration. Her general condition had remained unimpaired and she denied symptoms referable to the genitourinary tract. Urinalysis revealed a slight trace of albumin and rare leucocytes. An x-ray picture of the pelvic girdle showed a large area of bone destruction involving the superior and inferior ramus of the pubic bone, which was interpreted as being metastatic in nature (Fig. 2a). While a search was in progress for the primary lesion pyelograms were made which revealed a filling defect in the region of the inferior calyx of the right kidney (Fig. 2b). In addition there was an irregular outline of the right lower kidney pole and impairment of function of the right kidney. In view of these findings a diagnosis of cortical tumor of the right kidney metastatic to the right pubic bone was made. A thorough search for other metastatic lesions yielded negative results.

Treatment consisted of 200 kilovolts of x-radiation over the primary as well as over the secondary tumor. Irradiation resulted in marked improvement in the appearance of the bone lesion coinciding with complete disappearance of pain in the region of the right groin. X-ray studies made at 3 month intervals revealed gradual filling in of the osteolytic bone lesion. A film made on September 13, 1939, showed irregularity of the borders and several areas of rarefaction with evidence of new bone formation in the area affected (Fig. 2c). Pyelograms repeated on January 17, 1940, revealed very slight progression of the primary lesion but a new area of bone destruction in the region of the right pubic bone (Fig. 2d). A renewed course of 200 kilovolts of x-radiation over the symphysis resulted in temporary regression in the size of the rarefied area. However, the last x-ray film made on August 26, 1943, showed an extensive area of bone rarefaction involving the superior and inferior ramus of the pubic bone extending down to the ischium (Fig. 2e). Excretory urograms made recently showed fair elimination of diodrast from the right kidney and no essential changes in the appearance of the right kidney pelvis compared to the films taken 3 years ago. The patient's general health has remained good and she has lost no weight. Her blood count on August 26, 1943 was as follows: hemoglobin, 96 per cent; red cells, 4,800,000; and white blood cells, 12,400. The differential count was normal except for a moderate increase in band forms. Up to the time of writing, the patient had no hematuria or other symptoms referable to the genitourinary tract. On palpation, no tumor was felt in the kidney region and no evidence of metastases to other organs was demonstrable up to the time of writing.

END-RESULTS

Owing to the large number of patients with far advanced or metastatic lesions the results accomplished in our series of cases were most discouraging. Only 13 per cent of the patients survived 3 years, 6 per cent 5 years and 1 per cent 10 years.

At the time of writing 71 of our 100 patients had died of the disease, 59 of them within 1 year after admission. Four patients died of other causes and 10 could not be traced. Of the remaining 15 cases, 11 are alive with the disease and 4 are apparently well. Two of the latter 4 cases have been well

for less than 1 year, 1 for over 2 years, and 1 for more than 5 years.

Nephrectomy followed by external x-radiation was the method of choice in the treatment of patients with operable lesions (35 patients[1]). In patients who were admitted with a recurrent or inoperable tumor, treatment consisted in external x-radiation alone (50 patients). Patients in the terminal stages of the disease when first seen received no treatment (15 patients).

It is the consensus that irradiation treatment in patients with adult cortical kidney tumors is of little value as far as the ultimate outcome is concerned. Priestley, in his analysis of 395 cases, arrived at the conclusion "that no significant difference was noted in the survival rate of patients receiving irradiation and those receiving no such treatment." Our results are in agreement with Priestley's experiences. Although dosages of from 3000 to 4000 r were delivered to the tumor (200 kv., 70 cm. skin target distance, 0.9 mm. copper filter half value layer), no more than temporary regression in the size of the tumor was accomplished in isolated cases while the majority of the patients did not respond to irradiation treatment at all. It can be concluded, therefore, that parenchymal neoplasms of the kidney are radioresistant, and the amount of radiation required for their destruction is greater than can be tolerated by healthy tissue.

Study of our material has indicated that the course of an inoperable parenchymal tumor of the kidney is not so much determined by the kind of treatment employed as by the potential malignancy of the tumor itself. Although the majority of these patients die of the disease within 1 to 3 years after onset of symptoms caution should be used in making a prognosis since some of these patients may live quite comfortably for many years before they succumb to the disease.

SUMMARY

Data collected from 100 consecutive cases of cortical kidney tumor are presented. Seventy-three of the patients were admitted with inoperable, recurrent, or metastatic lesions, and 27 patients had early or moderately advanced tumors.

Only 4 patients are alive and apparently well; 11 are alive with the disease, 10 could not be traced, 4 died of other causes and 71 died of the disease.

Surgery offers the only chance of cure provided the tumor is still operable. External irradiation treatment is of little or no value in the majority of the cases because parenchymal neoplasms of the kidney are radioresistant.

It is emphasized that some of the patients with cortical tumors of the kidney may present symptoms lasting for many years prior to admission. These cases may continue to live for a considerable length of time before they succumb to the disease.

[1]Nephrectomy was carried out before admission in 23 of these 35 patients.

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SURGICAL DIVISION OF THE SPINOTHALAMIC TRACT IN THE MEDULLA

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ONE of the more efficient operative methods for the relief of intractable pain is that of cutting the lateral spinothalamic tract. This procedure combines simplicity of performance and permanency of analgesia without impairing motor functions, and therefore has largely replaced such methods as peripheral neurectomy and posterior rhizotomy. However, even this method has been unsuccessful in certain cases of severe unremitting pain in the neck and shoulder because the pain fibers from these regions are the most deeply placed in the lateral spinothalamic tract and often escape section. For this reason neurosurgeons are ever alert to the development of new techniques which offer promise of producing high levels of analgesia.

In 1941 Schwartz and O'Leary proposed sectioning the lateral spinothalamic tract in the medulla oblongata, much after the fashion of Sjöquist's operation for cutting the descending spinal root of the trigeminal nerve. They claimed to be successful in producing a high level of analgesia and in alleviating shoulder and neck pain in 2 cases. One of us has since employed this operation in 3 cases. In two the tract was sectioned on one side only, but in the third both sides were cut. All of these patients have subsequently died and have come to postmortem examination. The object of this paper is to relate our experience with this procedure, and to offer evidence to show whether or not this new method holds sufficient advantage over other methods to justify its continued use.

CASE REPORTS

CASE 1. The first patient operated upon was a 46 year old white male first seen in December, 1941, at the request of Dr. John Strieder. He had complained of cough, sputum, hemoptysis, dyspnea, and pain in the chest, for 10 months. He was first admitted to the Boston City Hospital on April 29, 1941, by which time a diagnosis of carcinoma of the right lung with metastases had been made. An exploratory thoracotomy revealed an inoperable tumor. He was discharged with the chest wound healed, May 19, 1941, suffering from continuous pain in the right chest, dyspnea, and small hemoptyses. The following October, the patient developed severe pain in the right knee and leg, and the foot became cold. He was readmitted in November, and a diagnosis of thrombosis of the right femoral artery was made. During all this period he had been taking increasingly larger doses of opiates without relief from his pain. At the time we saw him he required ¼ grain morphine or ⅔ grain dilaudid at least every 4 hours and sometimes oftener. Physical examination showed the trachea to be deviated to the right as was the mediastinum. The right chest expanded poorly. There was increased fremitus, decreased resonance, and absent breath sounds over the whole right chest. The fingers and toes were "clubbed" and arterial pulsation was absent in the right leg below the knee. There were no signs of neurological disease. Roentgenograms of the spinal column, 2 needle oxygen myelograms, and tests of the dynamics and chemistry of the cerebrospinal fluid disclosed no abnormality. The urine was normal; the blood examination was not made. The blood pressure was 112/86, the temperature 98 degrees, pulse 88, and the respiration 22. The patient's life expectancy was estimated as being 2 to 3 months.

Cordotomy with section of the spinothalamic tract offered the only hope for relief as he had reached the limit of toleration of opiates, and they had lost their effect. Because a classical thoracic cordotomy would not be high enough, and because a high cervical cordotomy might prove ineffectual in rendering the neck and shoulder analgesic, a medullary tractotomy was thought to be the procedure of choice. This operation was performed on January 20, 1942, under local anesthesia, with the patient's head on the cerebellar headpiece and elevated to 45 degrees above the horizontal. The usual trap-door incision with an extension across the midline for about 1 inch was outlined in the left occipital region, and the occiput and foramen magnum were exposed and cleaned without difficulty. The occipital bone on the left and a little of that on the right as well as the posterior half of the foramen magnum were completely removed. The dura was widely opened and the left hemisphere, the vermis, the medulla, and the upper end of the cervical cord were exposed. The tonsil on the left was loosened and this and the hemisphere gradually elevated and turned upward and medially after the cisterna magna and the

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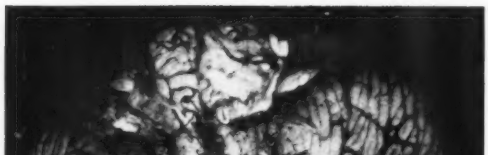

Fig. 1. Arrow indicates the site of the tractotomy. Note that the incision begins in the retro-olivary sulcus and extends posteriorly toward the restiform body.

lateral cistern were emptied and the arachnoid was torn over the 9th, 10th, and 11th cranial nerves. The left posterior cerebellar artery was very long, looped twice on itself, and overlaid the field of operation in the medulla. It was mobilized successfully, however, and the dorsolateral aspect of the medulla with the filaments of the 9th, 10th, and 11th nerves at their points of exit were exposed. There was a small vein in the dorsolateral sulcus. The olive and fibers of the hypoglossal nerve were easily identified. It was decided to cut the upper filament of the 11th nerve to procure more room for the tractotomy. This was done with the cutting electric current. A distance of 4 millimeters was then measured on a cataract knife and marked with bone wax. A point just beside and above the exit of the filament that had just been cut was selected, and the knife blade was inserted straight into the medulla for the 4 millimeters and then depressed and elevated in a half circle. This cut the vein in the posterolateral sulcus, but it did not bleed significantly. The patient had no reaction and testing with a pin on his right side demonstrated a complete loss of pain sense to about the 6th dorsal and hypesthesia above that level to 1st dorsal or 8th cervical segment. The tractotomy was then repeated at a depth of 5 millimeters. This produced pain in the left eye at the posterior end of its arc in the medulla but no further anesthesia. The blade was then inserted to a depth of 6 millimeters. This produced pain in the left eye at the posterior end and pain in the throat at the anterior end of the arc and analgesia to the level of the 8th cervical dermatome. As much had been done as was considered safe by then and no further attempts were made to reach the more deeply situated cervical fibers. The patient had shown no reaction. The blood pressure remained between 115/95 and 120/90; the pulse ranged between 120 and 140 and the respiration stayed between 20 and 25. The wound, including the dura, was closed as usual without drainage and with interrupted silk sutures, pentothal being given during the closure. At the end of the operation the blood pressure was 115/85, the pulse 125 and the respiration 27. At the start the figures had been, blood pressure 115/90, pulse 155, and respiration 27. The patient responded satisfactorily at the end of the operation. No further narcotics were needed after the 4th postoperative day. On the 8th day he was out of bed, around the ward and free of pain. The only complication was some difficulty in swallowing on the 2d day. This disappeared in 12 hours. On the 2d day, the upper level of hemianalgesia on the right was at the 8th cervical-1st dorsal segment. By March 8, which was the 19th post-operative day, the upper level had descended to the 5th dorsal. Below this the sensation of pain and temperature was lost and that of light touch was diminished. On April 14, the patient was much weaker and had to be confined to bed. At this time he was disturbed by paranoid delusions and required sedation. He died suddenly on April 16, 76 days after the operation.

An autopsy, restricted to examination of the brain and spinal cord, was performed 8 hours after death. The pathological diagnoses were: left lateral medullary tractotomy, postoperative, with section of the left lateral spinothalamic tract, the left ventral spinocerebellar tract, and parts of the left central tegmental tract, left nucleus ambiguous, and dorsal accessory olivary nucleus.

The craniotomy wound was cleanly healed. Just behind and about 0.5 centimeter above the lower pole of the left olive was a small notch which represented the site of the tractotomy (Fig. 1). The spinal portion of the left spinal-accessory nerve was softened and retracted. Horizontal section of the medulla at the level of the incision revealed a linear cavity just behind the left olive. The cerebrum, brain stem, and spinal cord were otherwise normal. No tumor metastases were present.

The entire medulla was cut into small blocks and sectioned serially. Sections were stained by the methods of Nissl and Weil. Representative blocks of spinal cord, cerebellum, pons, midbrain, and cerebrum were prepared by the same methods.

The operative lesion was best demonstrated at about the midolivary level. Here it was situated just behind the olive and extended medially to within 2.0 millimeters of the midline (Fig. 2). At one point it bifurcated and extended forward into the dorsal accessory olivary nucleus. The vertical extent was about 2.5 millimeters. The left lateral spinothalamic tract, except possibly some of the most medially placed fibers, the ventral spinocerebellar tract, the central tegmental tract on the left, the ventral part of the nucleus ambiguous, and the dorsomedial part of the inferior olivary nucleus were either destroyed or interrupted. The pyramidal tracts, medial lemnisci, except for a few ventral fibers, and the spinal nucleus and tract of the trigeminal nerve were not involved.

Secondary degeneration of the olivocerebellar and dorsal spinocerebellar fibers could be traced to the left restiform body. No other ascending or

descending degeneration was observed. (Marchi technique was not employed because of the age of the lesion.) Cresyl violet sections revealed large numbers of macrophages at the site of the lesion and gliosis of the surrounding tissue.

It is evident from the clinical and anatomical findings that the nucleus ambiguous, spinal nucleus, and the tract of the trigeminal nerve were not damaged to any significant degree. The spinocerebellar tracts, especially the ventral one, were partially interrupted, but no cerebellar signs were produced. Although successful in relieving the chest pain the highest level of the analgesia was only the cervical 7th-8th. Thus some of the most medially placed fibers, those just decussated and conveying sensation from neck and shoulder were not severed at the operation.

CASE 2. The second case was a man of 57 years, seen April 13, 1942, in consultation with Dr. Somers Fraser. He complained of pain and swelling of his left leg. This had started in September, 1941, to be followed shortly afterward by the appearance of a mass in the left groin. This mass was removed in October, 1941, and a diagnosis of epidermoid carcinoma was made by the pathologist. No primary site could be found. A lymph fistula and swelling of the leg followed but subsided after 16 days. However, his pain continued and became progressively worse. X-ray therapy was given without relief, at another institution. He became progressively more emaciated and was readmitted under Dr. Fraser's care on March 12, 1942. On March 31 an intrathecal alcohol injection was done but no relief from the pain was obtained. On April 3, section of the spinothalamic tract in the medulla was advised, because the original site of the malignant lesion had not been demonstrated; because a high thoracic cordotomy might prove ineffective later on; and because he had reached his limit of tolerance to opiates without relief of his pain.

Physical examination revealed emaciation, lymph edema of the genitals and left leg, ascites, and palpable glands in the rectal shelf. There were many red and white blood cells in every specimen of urine which, except for a slight trace of albumin, was otherwise negative. He had a hemoglobin of 62 per cent, a red blood cell count of 3.35, and a white blood cell count of 27 thousand. Lumbar punctures and studies of the cerebrospinal fluid were repeatedly negative as were x-ray films of his bones. A 7 foot film of the chest showed a healed tuberculous lesion in the right upper lung field, a prominence of the left ventricle, and a widened aorta. A diagnosis of aortitis was made.

On April 8, a section of the spinothalamic tract in the right half of the medulla was carried out. The approach through the right side was similar to that described. There was some difficulty with hemorrhage in the latter part, however, because of the patient's lack of co-operation and he had to have ¼ grain morphine which was given subcutaneously. This quieted him and hemostasis was attained eventually. The dura was opened widely down to the arch of the atlas and the right cerebellar hemisphere, the vermis, the junction of the medulla and the cervical cord were well exposed. The posterior cerebellar artery came up into and looped twice upon itself in the wound. However, after a careful division of the arachnoidal adhesions which held it to the side of the medulla, it was possible to mobilize this artery sufficiently so that it could be held out of the field until after the medulla had been incised. The 10th and 11th nerves were identified at their points of origin and the area on the side of the medulla between the two nerves was wiped clean of a plexus of small veins. Because of the shape of the patient's posterior fossa, it was difficult to approach this lateral aspect of the medulla at right angles, and there was some doubt as to the success which would attend attempts at section of the tract. Furthermore, the patient, as a result of the morphine that he had had, now became so deeply anesthetized that only severe painful stimuli would awaken him. Fortunately, he responded to pain when the 5th nerve area was touched with the knife, and it was possible to identify that area by the aid of prickings with the cataract knife. Having located the lateral border of this area, a distance of 4 millimeters was measured off on the knife tip and marked with bone wax. The knife was inserted as nearly at right angles to the side of the medulla as possible immediately beside and above the superior filament of the 11th nerve. The knife had to enter the medulla at an angle of about 30 degrees but within that limit it was possible to make a circular cut within the substance of the medulla. It was impossible to determine success or failure of this intramedullary incision because the patient did not respond to pin prick on the opposite side of his body. For fear that all of the spinothalamic tract had not been cut, a curved, pointed Bard-Parker knife was inserted with the cutting edge up

Fig. 2. The medulla oblongata at the level of the inferior olivary nucleus. Arrow indicates site of the left lateral medullary tractotomy.

to a depth of 5 millimeters into the same incision that had already been made. By pulling it out with the curve of the tip pointed posteriorly, this completed the posterior part of the section. Because of previous experience in the last case, and because of our inability to demonstrate any analgesic effect on account of the patient's general anesthetic condition, 5 millimeters were then measured off from the tip of a cataract knife and that instrument inserted into the wound. The blade was swung anteriorly so as to deepen the anterior half of the section. Again attempts were made to determine whether or not the patient was analgesic, but they failed. There was no bleeding from the medulla or anywhere else at this time, and the wound was then closed in layers without drainage in the usual manner. The incisions in the medulla caused no change in blood pressure level. The patient's condition was satisfactory throughout the operation except for his unco-operativeness. He was returned to bed in good condition immediately after the closure.

On April 11 symptoms of high intestinal obstruction with fecal vomiting developed. This was relieved by the use of the Miller-Abbott tube and other appropriate measures, and on April 14 the tube could be withdrawn. He was completely relieved of pain and required no opiates following the medullary tractotomy. As nearly as could be told he had anesthesia to pain and temperature on the left up to the level of 8th cervical-1st dorsal segment. His carcinomatosis and cachexia advanced rapidly after the operation, however, and he died quietly on April 25, 1942, 14 days after the tractotomy.

Postmortem examination demonstrated the following: poorly differentiated, rapidly growing squamous cell carcinoma of the urinary bladder with invasion of the rectum and regional lymph nodes and with metastases in the lumbar vertebrae; bilateral bronchopneumonia; bilateral hydroureters and hydronephrosis; healed bilateral apical tuberculosis; lateral medullary tractotomy, right, postoperative; and cerebellar hemorrhage, which was probably operative.

At about the junction of the medulla and spinal cord, 0.7 centimeter below and just lateral to the right olivary body there was a small, slightly yellowish depression which measured 0.2 by 0.3 centimeter (Fig. 3). All the cranial nerves appeared to be undamaged except possibly the spinal portion of the spinal accessory. A horizontal section of the medulla revealed a soft, grayish-yellow lesion in the lateral tegmentum of the medulla which had a vertical extent of 0.5 centimeter. In the central white matter of the right cerebellar hemisphere was a hemorrhage which had a diameter of 1.3 centimeters. It showed a moderate degree of encapsulation. No other abnormalities of the spinal cord, brain stem, or cerebrum were detected. There were no intracranial tumor metastases.

The brain stem and spinal cord were cut into blocks and sections were stained by the methods of Marchi, Weigert, and Nissl.

The operative lesion was situated at the level of the decussation of the pyramids in the lateral column and lateral reticular substance (Fig. 4). It extended medially to within 0.3 or 0.4 centimeter of the midline and had a vertical extent of approximately 0.5 centimeter. In the lesion are several small hemorrhages 2 to 3 millimeters in diameter. The anatomical structures involved were: the spinal tract and nucleus of the trigeminal nerve, the dorsal and ventral spinocerebellar tracts and the lateral spinothalamic tract, all on the right side. The lesion did not extend to the pyramids or dorsal columns. There were large numbers of macrophages laden with fat and hemosiderin in the lesion.

There was ascending degeneration of the dorsal spinocerebellar tract into the restiform body and of the ventral spinocerebellar tract as far as the upper level of the pons. The latter could not be traced into the superior cerebellar peduncle. The ascending degeneration of the lateral spinothalamic tract could be followed to the lower mesencephalon but was lost at that point. Throughout the entire length of the left column of Goll there was degeneration of myelin. No definite evidence of descending degeneration was seen.

The leptomeninges over the medulla and cerebellum were moderately infiltrated with lymphocytes and a few plasma cells. Small collections of such cells were found in the spinal meninges of the cervical spinal cord.

Around the cerebellar hemorrhage there were large numbers of macrophages filled with hemosiderin, and an increase in the number and size of the astrocytes in the adjacent tissue.

Again some of the medially placed fibers of the lateral spinothalamic tract carrying pain and temperature for the arm and shoulder escaped section, thus accounting for the absence of hypalgesia above the level of the 4th dorsal segment. Unlike the first case the lesion in the medulla was much more extensive both horizontally and vertically because of the hemorrhage which probably resulted from section of a small vessel. The hemorrhage in the cerebellum, judging from the amount of organization which had occurred, probably happened at the time of operation when the cerebellum was manipulated to afford a better exposure.

The menigeal reaction was probably related to the operation and could have been caused by a slight, localized postoperative infection.

CASE 3. A woman of 52 years, referred by Dr. Charles W. Meyers of Indianapolis, Indiana, was first seen by one of us at the Boston City Hospital on April 15, 1942. She had complained of pain in her left leg for the previous 6 months. She had been well

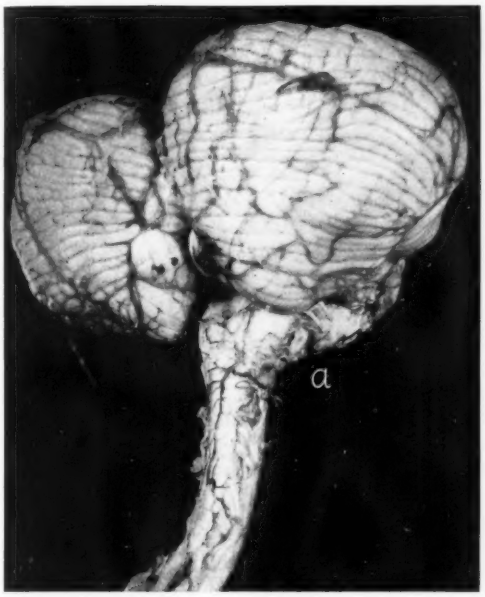

Fig. 3. The cerebellum, medulla and upper end of the spinal cord. a, Site of right lateral medullary tractotomy.

until February or March, 1941, at which time she consulted her physician about some vaginal discharge. She was told that she had a malignant tumor of the uterine cervix and was treated with radium and by x-ray. After a short period of improvement the pain recurred in both thighs and was accompanied by lower abdominal discomfort. In November, 1941, both ovaries and the body of the uterus were removed, the cervix being left in place. This gave her no relief from her pain so an intrathecal injection of alcohol was attempted. This, too, was unsuccessful, and, following it, she developed severe pain involving the entire left leg, numbness of both feet and ankles and fecal incontinence. She gradually lost weight and strength, had to use large amounts of dilaudid to control her pain, and had been bedridden for 5 months previous to her admission to the Boston City Hospital. She developed a sensitivity to morphine and recently had had frequent episodes of nausea and vomiting accompanying her pain. Physical and neurological examinations were negative except for cachexia, a healed suprapubic scar, generalized asthenia, pin-point pupils, anesthesia of the left labia majora, hypesthesia of her left foot and ankle, and a diminished knee and absent ankle jerk on this side. Her blood pressure was 110/90. Her urine was full of red and white blood cells with a slight trace of albumin. She had a hemoglobin of 64 per cent, a red blood cell count of 3.6, and a white blood cell count of 15 thousand. Her nonprotein nitrogen was 27.

Fig. 4. The medulla oblongata at the level of the decussation of the pyramidal tracts. Note the extensive degeneration of the myelinated fibers lying between the spinal nucleus of the trigeminal nerve and the pyramidal tract on the right.

Because of the possibility of high spinal metastases, a section of both spinothalamic tracts in the medulla, each side being done separately and with an interval between, was advised. The tract on the right side was sectioned on April 27, 1942, through a right-sided approach as described. The dura was widely opened in such a way as to expose the right cerebellar hemisphere, the vermis, and the junction of the medulla and the spinal cord. The right cerebellar hemisphere was freed from a few filmy attachments to the medulla and turned upward and medially, thus exposing the right side of the medulla. The calamus, the 10th and 11th nerves and their points of origin from the side of the medulla were identified. The 12th nerve could be easily seen in front of these others. The surface of the medulla next to the exit of the uppermost filaments of the 11th nerve was covered by a plexus of small veins. These were gradually brushed to one side until a cleared area was obtained. None of the larger vessels interfered in any way with the field. Five millimeters were measured from the tip of a cataract knife and marked with bone wax and the knife inserted into the medulla at what was believed to be the proper point. This produced pain in the patient's lower jaw, however, so it was evident that the insertion was too far posterior. A point more anterior was chosen and the knife inserted to the depth of 4 millimeters without causing pain. It was then swung in an arc forward and backward, the extreme backward arc causing pain in the patient's nose. The patient was then tested for analgesia with a pin, and it was found that she was analgesic up to

the level of the lower angle of the scapula. The knife was again inserted, but this time to a depth of 5 millimeters and again swung in an arc and again caused pain in the nose at the same place. Testing demonstrated that there had been a slight rise in the analgesic level to perhaps the middle of the scapula. Six millimeters were now measured on the cataract knife tip and marked with bone wax, and then the knife was inserted for a 3d time. Following this, the anesthetic level rose to about the level of the shoulder. Pain was again caused in the nose at the posterior extremity of the arc, but no pain was caused in the larynx. There was a small amount of bleeding following this from a surface vein which had been divided. This stopped very promptly leaving, however, a certain amount of clotted blood which surrounded the filaments of the 10th nerve. This could not be removed by wiping, suction, or irrigation so, rather than endanger the 10th nerve, it was left in place. The wound was then closed in layers without drainage and the patient was returned to bed in excellent condition. During the operation, at the time the cistern was drained the patient's blood pressure dropped from 135/80 to 100/70. However, it rose again immediately thereafter and 10 minutes later, at the time of the incision of the medulla, was back to 140/80. Following this incision and for the next fifteen minutes, it was 160/100. Thereafter it fell in the course of another 10 minutes to 145/95 and in another 5 minutes to 125/95, where it remained until the end of the operation. The anesthesia was entirely satisfactory and the patient was able to co-operate throughout the operation.

Her convalescence was uneventful, and on May 4 it could be demonstrated that she had no pain sensation on the left side of the body below the 2d rib. She still required dilaudin and still complained of pain in her abdomen and right leg, however. On May 8, 1942, the second operation was performed and the spinothalamic tract cut in the left half of the medulla by a technique similar to that described. The dura was reopened, there being a little difficulty from bleeding and the left cerebellar hemisphere was exposed. The cistern had not healed and the cerebrospinal fluid over the medulla was lying under the dura and outside the cisternal wall. This was drained off and the left cerebellar tonsil was lifted out of the remains of the foramen magnum, and the left lateral aspect of the medulla was exposed. The patient had been somewhat restless up to this time, and now her restlessness brought about a condition in which she was causing increased bleeding and difficulty in the operation so she had to be given ⅔ grain of pantopon. This quieted her markedly—in fact she became unresponsive to peripheral stimulation. Even though her active co-operation was desirable, it was thought inadvisable to wait for the effects of the medication to wear off. An area on the lateral aspect of the medulla immediately superior to the upper filament of the 11th cranial nerve was therefore prepared. A plexus of small veins lying in the pia in this region had to be scraped away, and there was also some difficulty in rotating the medulla sufficiently so that a straight knife could be used to make the medullary incision. Despite these difficulties, the original medullary incision was made with a straight cataract knife which was inserted to the depth of 5 millimeters and turned in an arc. As there was some doubt as to the efficacy of this incision, a fine hooked knife was then inserted for a distance of 6 millimeters, its point being swung in an arc also. There was no bleeding from the medulla, and no effects on the patient other than a rise of pulse rate from 110 to 120. The dura was closed. Because of a fall in the patient's blood pressure, a blood transfusion was started and the rest of the operation was postponed for a short time until the transfusion was ended—a matter of half an hour or so. Her blood pressure then rose and the closure was completed. The patient was in fair condition at the end of the operation and was returned to her bed at once.

On May 10 she appeared to have no pain on either side of her body from the clavicles down and sensation on her face appeared limited. Opiates were no longer required. Later, on May 23, it appeared as though she did have some pain on the right side of her body, although she refused to describe her sensations as being painful. Empirin compound given every 4 hours in 5 or 10 grain doses kept her comfortable. After a period during which the infection in her bladder caused trouble, she developed pain in the region of her shoulders and head. Snake venom in gradually increasing doses was commenced on June 11 and was successful in controlling this pain until her death. On June 26 the midpoint of the cross bow operative incision became necrotic and she began to slip downhill rapidly. She developed a vesicovaginal and after that a vesicointestinal fistula. A week before her death an intestinal fistula broke open in the abdominal scar. She died quietly and comfortably on August 19, 1942. This was 115 days after the first operation and 103 days after the second.

The findings at postmortem examination were as follows: carcinoma of the cervix with spread to the lymph nodes locally, the small and large bowel, the rectum, the bladder and the skin; a fistulous tract connecting the rectum and small bowel with the vagina, the bladder and the anterior abdominal wall; a stricture of left ureter with hydroureter and hydronephrosis; chronic cholecystitis with cholelithiasis and infectious biliary cirrhosis; and bilateral medullary tractotomy, postoperative.

All cranial nerves appeared to be intact save for a few filaments of the right vagus which were soft and gray white. On the right lateral surface of the medulla, 0.2 centimeters below the olive and just posterior to the retro-olivary sulcus, there was a small depressed area which was softer than the surrounding tissue. This probably represented the site of the right tractotomy. No visible evidence of the left tractotomy which had been performed was present externally.

Fig. 5. Horizontal section through the medulla showing the sites of the bilateral tractotomy in Case 3.

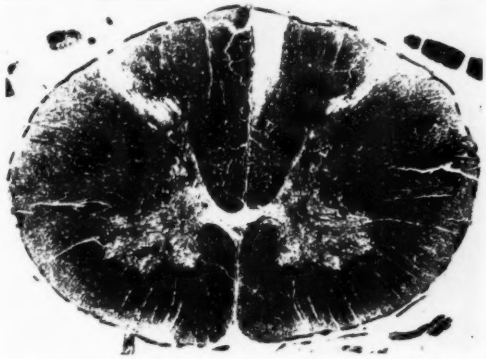

Fig. 6. Horizontal section through the cervical spinal cord. Note the degeneration of the column of Goll on the right. This was ascending in type and secondary to lumbosacral nerveroot damage caused by the intrathecal injection of alcohol.

Upon section of the medulla in the horizontal plane yellow-gray softened areas were found bilaterally in the lateral reticular zone. The left column of Goll was gray throughout its length in the spinal cord. No sign of tumor metastases was noticed. The medulla was divided into blocks and representative blocks were taken also from the spinal cord, pons, midbrain and thalami. Sections from all blocks were prepared by the Weigert and Nissl methods.

The lesions caused by the operations were situated in the retroolivary regions bilaterally (Fig. 5). That on the right side extended about 0.3 centimeter posterior to the olive and medially to a depth of 0.7 centimeter. The structures which were destroyed or interrupted were the lateral spinothalamic tract except for the medial fibers, the ventral spinocerebellar tract, the external arcuate fibers, a few fibers and cells of the spinal tract and nucleus of the 5th nerve and part of the dorsal accessory olive. There was no definite ascending or descending degeneration.

The lesion on the left side was smaller than the right one. It extended medially to a depth of 0.5 to 0.6 centimeter and had an anteroposterior diameter of 0.2 centimeter. It had destroyed or interrupted all the spinothalamic tract, except the most medially placed fibers, the ventral spinocerebellar tract, and a few fibers and cells of the spinal tract and nucleus of the trigeminal nerve. In both of these lesions only a few myelinated tracts were present. The other nerve fibers had degenerated and been replaced by macrophages filled with fat. There was a foreign body giant cell in the left lesion. The left column of Goll and the left dorsal and ventral roots of the lumbar cord had degenerated (Fig. 6). The anterior horn cells in the 5th lumbar segment were rounded and showed central chromatolysis—"axonal reaction."

Neither of the incisions was deep enough to sever all the most medially placed fibers of the lateral spinothalamic tracts; more escaped on the left than on the right. This accounts for the preservation of pain and temperature senses in the neck. The degeneration of the dorsal and ventral roots of the lumbar cord is believed to have occurred either because of the intrathecal injection of alcohol or the vertebral metastases. The intramedullary extensions of these lumbar root fibers, the column of Goll, had secondarily degenerated.

OBSERVATIONS FROM STUDY

A study of these 3 cases justifies certain conclusions relative to the danger and technique of the operation, the results to be expected from it, and its place among neurosurgical procedures for obtaining relief from pain.

The danger of the operation done under proper conditions and by one familiar with the field appears to be minimal. The patients reported herein were the worst possible type of surgical risk, nevertheless they had little if any postoperative reaction. The operation should, if at all possible, be done under local anesthesia and with the patient's head 45 degrees higher than his feet. Enough bone should be removed to allow for easy mobilization of the cerebellar hemisphere and posterior cerebellar artery and should include that in the midline of the occiput and the posterior half of the foramen magnum.

The best that can be expected in terms of analgesia from this operation is relief of pain from the level of the clavicle downward. This procedure will not produce analgesia in the shoulders, arms, neck or head. High cervical spinothalamic cordotomy, section of posterior spinal roots, and division of certain cranial nerves are necessary if these areas are to be included in the analgesic area. We see no reason why this medullary tractotomy cannot be combined with section of any of the appropriate cranial nerves in the posterior fossa, however, keeping in mind that a bilateral posterior fossa craniotomy has to be made in that case. From the clinical and technical point of view, medullary tractotomy, whether unilateral or bilateral, will prove ideal in those cases in which a thoracic cordotomy can be expected to be ineffective because of the high level of trunk pain or the possibility of high lung or spine metastases. If, however, the object of the operation is to divide the cervical and brachial fibers in the spinothalamic tract, then the operation has little to recommend it over a high cervical cordotomy combined with section of posterior roots in the upper cervical region. At least in all our cases we were unsuccessful in producing analgesia of the neck and shoulder.

Although anatomically the most favorable site for section of the spinothalamic tract in the medulla is at the inferior pole of the olive, from an operative technical point of view the location of the uppermost radicle of the 11th cranial nerve will determine the site in the vertical plane while the production of pain in the 5th nerve by prodding the surface of the medulla provided the patient is conscious, will determine the horizontal site of insertion of the knife. Judging from this experience 5 millimeters is a safe depth for the medullary incision although 6 millimeters, if it can be used, is probably preferable. Anterior and posterior limits of the swing of the knife are determined by pain in the face on the one hand and in the throat on the other. Bilateral section, if separated by a short interval, appears to be safe. There is still some question as to the optimal level within the medulla at which the section should be made. In the first case the incision was placed about 0.5 centimeter above the level of the inferior pole of the olive; in the 2d case it was at the junction of the medulla and cervical cord; in the 3d case the incisions were about 0.2 centimeter below the inferior pole of the olive. The level should be determined by the accessibility of the lateral spinothalamic tract, the prominence of landmarks, and the proximity of other important neurological structures and blood vessels.

In consideration of these points we propose that the preferred operative site be the inferior pole of the olive because (a) most of the high cervical secondary neurones for pain and temperature should have decussated by then, (b) the olive and retro-olivary sulcus are good landmarks, (c) the 9th and 10th cranial nerves, restiform body, and pyramidal tract decussation are sufficiently remote to avoid injury.

We agree with Grant and Weinberger, J. C. White, and Schwartz and O'Leary that tractotomy is a feasible procedure and can be performed even bilaterally without danger to life. This is contrary to the old teaching that the medulla is a vital organ the slightest injury of which will be fatal. It is well to remember that most nuclear masses, not only in the spinal cord but also in the brain stem, are represented for a considerable distance vertically and that a horizontally placed surgical incision will damage relatively few nerve cells. There is some danger of hemorrhage from severance of a small intramedullary vessel.

Only 1 of the 3 cases was suitable for studying the central course of the spinothalamic fibers by the Marchi technique. Other investigators, (Goldstein, Foerster, Walker, for example) have succeeded in following this tract to its central termination in the posterolateral nucleus of the thalamus. Our failure to trace it above the pons was probably because of the fault of the Marchi technique used in our laboratory.

SUMMARY AND CONCLUSIONS

The cases of 2 patients in whom a unilateral section of the spinothalamic tract, and of 1 in whom a bilateral section of the spinothalamic tract was carried out in the medulla, are discussed in detail.

All patients survived their respective operations.

In every instance the operation was followed by analgesia extending downward from about the level of the 2d thoracic dermatome on the appropriate contralateral side of the body. No analgesia was produced above the clavicles.

Postmortem studies of the 3 medullas demonstrated that it is impossible to cut the cervical portion of this tract in the medulla without causing crippling and unjustifiable damage.

Clinically if the operation is done under local anesthesia, the most satisfactory point of entry of the knife is at the level of the uppermost filament of the 11th cranial nerve. Its location in the anteroposterior direction will be determined by the production of pain in the face. The point of entry is just anterior to this point. The depth of the incision must not be less than 4 millimeters, but in our experience cannot exceed 6 millimeters because of involvement of the 10th cranial nucleus anteriorly and the tract of the 5th nerve posteriorly.

Anatomically the ideal point of section is at the inferior pole of the olive.

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THE USE OF PECTIN AND OTHER AGENTS TO PREVENT SHOCK

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PECTIN is a colloid carbohydrate obtained from vegetables and fruits[1]. It is better known to the profession as a substance used for oral therapy in certain intestinal ailments.

The use of pectin solution has been advocated as a blood and plasma substitute in the treatment of shock (9). It leaves the blood stream slowly due to its high molecular weight. It can be made into solution isotonic with blood, exerting an osmotic pressure, and possessing a viscosity similar to that of whole blood (15). It does not have any cumulative effect, and is retained in the circulation for some time—4 to 24 hours (2); being excreted unchanged in the urine. It is nonantigenic and innocuous. Pectin solution can be obtained and processed more economically than can plasma.

In traumatic shock when there is a loss of plasma at the site of injury or systemically due to increased permeability of the capillaries (3, 4, 12), the use of crystalloid solutions such as isotonic saline and glucose is of transitory value (1, 11); in fact they may be harmful if given in large amounts, because they tend to leave the vessels quickly (1, 3, 4), carrying protein along with the fluid, producing tissue edema, and lowering the already depleted plasma volume to a critical level (7, 10).

Blood and plasma, when available, are the most suitable fluids in the treatment of shock; therefore, the use of pectin or similar substances would be considered chiefly in the absence of sufficient quantities of blood or plasma. The efficacy of the pectin solution depends somewhat on the method of preparation and sterilization. The solutions that we used in our experiments were clear and free of pyrogen.

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[1]The pectin used in this experiment was pure grapefruit pectin.

INTRAVENOUS USE IN ANIMALS

Exclusive of hemorrhage, the exposure and massage of intestines has been considered one of the best methods for producing experimental shock (16). We decided first to investigate the effectiveness of pectin in the prophylactic and active treatment of shock in animals (dogs). Although hemorrhage is an effective way of producing shock, we thought results would be more significant if we did not utilize hemorrhage as the sole factor in the pathogenesis of shock. Early in the massage there is an edema of the intestines with a consequent increase in volume. However, later the edema disappears; plasma-like fluid exudes from the surface of the bowel in sufficient amount to contribute to the fall of blood pressure (4, 5). In these animals, pulling on the stomach, the abdominal side of the diaphragm, the duodenum, the upper parietal peritoneum, or putting ice cubes in the upper abdominal cavity did not cause a sufficiently constant fall in blood pressure to utilize such procedures in our experiments.

EXPERIMENT 1. (Control vs. physiologic saline). The experiments were performed on healthy dogs, 18 to 26 pounds in weight. Ether was used as the anesthetic, and the narcosis was maintained by tracheal insufflation. The arterial blood pressure was recorded by a mercury manometer, attached to a cannula containing 5 per cent sodium citrate solution and inserted in the femoral artery. The blood pressure changes were recorded every 5 minutes. The intestines were brought out through a median abdominal incision, and traction was exerted on the mesentery while the loops of bowel were constantly and severely massaged until a blood pressure fall of 50 millimeters of mercury was reached and maintained for 10 minutes. To eliminate error as much as possible, manipulation was done by one person; a handful of intestine was squeezed 50 times per minute.

Controls. Seven healthy dogs were shocked by intestinal manipulation and the blood pressure recorded. It will be noted (Fig. 1) that it required an average of 54 minutes of constant and severe massage to lower the blood pressure 50 millimeters of mercury. There was an immediate fall of blood pressure of 18 millimeters of mercury within 10

minutes. After this, the fall in blood pressure became more gradual, until the shock level was reached; then there was another sharp drop. The animals were killed with an overdose of ether.

Effect of physiologic saline. Eight dogs were given 300 cubic centimeters of physiologic saline solution before the manipulation of the intestines and 200 cubic centimeters during the trauma. The blood pressure was recorded every 5 minutes.

There was an immediate fall in blood pressure of 10 millimeters of mercury within the first 10 minutes of manipulation as noted in the controls. In every animal the blood pressure was sustained for some time, the average being 10 minutes, after which the blood pressure began to fall again. It required an average of 62 minutes of intestinal trauma to lower the blood pressure 50 millimeters of mercury; thus physiologic saline solution delayed the 50 millimeters of mercury fall in blood pressure only 8 minutes longer than those which received no medication (Fig. 1.)

EXPERIMENT 2 (One per cent pectin solution). In this group 10 dogs were used and 1 per cent pectin solution was injected, 300 cubic centimeters before manipulation of intestines and 200 cubic centimeters during the trauma.

There was no immediate fall of blood pressure in these dogs as in those used as controls or those that received physiologic saline solution. The blood pressure remained at normal level for a period of 20 minutes before it began to fall. This group of 10 dogs required 82 minutes of intestinal manipulation to lower the blood pressure 50 millimeters of mercury. This is a delay of 28 minutes over the controls and 20 minutes over the animals which received physiologic saline. Obviously, the 1 per cent pectin solution was responsible for delaying the occurrence of shock.

EXPERIMENT 3 (One per cent pectin plus physiologic saline). This series of animals received 500 cubic centimeters of a solution consisting of 250 cubic centimeters of physiologic saline and 250 cubic centimeters of 1 per cent pectin solution, administered in the same manner as in the previous experiments. There was an immediate fall in blood pressure, but it required 81 minutes of intestinal manipulation to lower the blood pressure 50 millimeters of mercury. This fall occurred at about the same rate as in those animals which received the 1 per cent pectin solution.

EXPERIMENT 4 (Blood serum). In this group of 6 dogs, 250 cubic centimeters of serum was injected at the same time that intestinal trauma was started. The serum was prepared from defibrinated dog's blood by whipping it with a very flexible test tube brush and centrifuging it for 35 minutes.

There was an immediate but slight fall in blood pressure within the first 10 minutes of intestinal manipulation. It required 113 minutes of manipulation to lower the blood pressure 50 millimeters of mercury, or 59 minutes longer than the controls (Fig. 1).

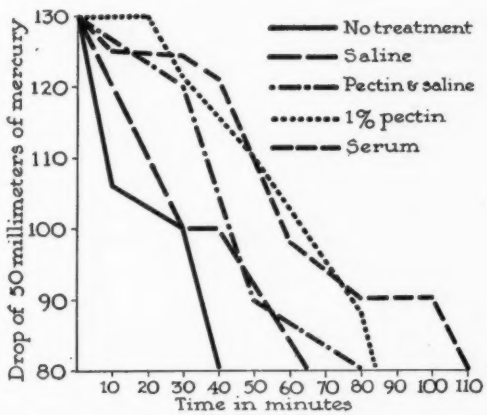

Fig. 1. Type and fall of blood pressure during manipulation of the intestine with and without treatment.

These results indicate that dogs to which pectin solution is given are more resistant to shock than are dogs to which no treatment or physiologic saline is given while the intestines are massaged. However, the pectin was not so effective as serum in preventing shock.

EXPERIMENT 5 (Other therapeutic agents). Other therapeutic agents were used to determine their benefit on the experimental animal in preventing the onset of shock.

a. Adrenal cortical extract. Five dogs were used. Each animal received subcutaneously 0.5 cubic centimeter of adrenal cortical extract per pound of body weight in 5 divided doses, each dose being 30 minutes apart. Ninety minutes after the initial dose was given, intestinal manipulation was started. There was no immediate fall in the blood pressure as occurred in all of the previous experiments (with the exception of those animals which received 1 per cent pectin). It required 89 minutes to lower the blood pressure 50 millimeters of mercury. Adrenal cortical extract was surpassed only by serum in delaying the 50 millimeter fall of blood pressure (Table II).

b. Adrenal cortical extract plus saline. Seven dogs were used. They received 500 cubic centi-

TABLE I.—TIME REQUIRED TO LOWER BLOOD PRESSURE 50 MM. OF MERCURY BY INTESTINAL MANIPULATION AND WITH CERTAIN TYPES OF THERAPY.

Solution	Time—minutes
Controls (no medication)	54
Saline, 500 c.c.	62
Pectin, 1 per cent, 500 c.c.	82
Pectin, 1 per cent, 250 c.c. plus 250 c.c. saline.	81
Serum, 250 c.c.	113

TABLE II.—COMPARISON OF DROP IN BLOOD PRESSURE WITH VARIOUS THERAPEUTIC AGENTS DURING MANIPULATION OF THE INTESTINE

Solutions	Drop in blood pressure —mm. Hg. 40 minutes' manipulation	60 minutes' manipulation
Controls	42	58
Physiologic saline, 500 c.c.	28	48
Pectin solution, 500 c.c. 1 per cent	11	29
Pectin, 250 c.c. 1 per cent plus 250 c.c. physiologic saline	26	46
Serum, 250 c.c.	14	34
Adrenal cortical extract	10	24
Adrenal cortical extract plus physiologic saline (500 c.c.)	24	38
Adrenal cortical extract plus 1 per cent pectin (500 c.c.)	8	10
Adrenal cortical extract plus 1 per cent pectin (250 c.c.) and physiologic saline (250 c.c.)	10	30
Adrenal cortical extract plus serum (250 c.c.)	4	14

It is evident that pectin, serum, and adrenal cortical extract inhibit the fall in blood pressure.

meters of physiologic saline solution to which had been added 0.5 cubic centimeter per pound of body weight of adrenal cortical extract. This solution was administered in the same manner as in the previous experiments. The blood pressure was maintained at a normal level for 10 minutes of intestinal manipulation before it dropped. Ninety minutes of intestinal manipulation was required to lower the blood pressure 50 millimeters of mercury; a delay of 37 minutes over the dogs which received physiologic saline solution alone.

c. Adrenal cortical extract plus 1 per cent pectin solution. Five dogs were used. They received 500 cubic centimeters of 1 per cent pectin to which had been added 0.5 cubic centimeter per pound of body weight adrenal cortical extract. In this group the blood pressure was maintained at the normal level for 10 minutes before the blood pressure began to fall. The animals in this group required 110 minutes of intestinal manipulation to lower the blood pressure 50 millimeters of mercury. The medication delayed the onset of the fall of blood pressure to shock level 28 minutes longer than the group which received 1 per cent pectin without the adrenal cortical extract.

d. Adrenal cortical plus pectin plus saline. Five dogs were used. They received intravenously 500 cubic centimeters of a solution which contained 250 cubic centimeters of 1 per cent pectin, 250 cubic centimeters of physiologic saline solution, and 0.5 cubic centimeters per pound of body weight of adrenal cortical extract. The blood pressure was maintained at normal level for 20 minutes of intestinal manipulation before a drop was noted. These animals required an average of 70 minutes of intestinal manipulation to lower the blood pressure 50 millimeters of mercury. This is 18 minutes longer than was required to lower the blood pressure to a similar level in the animals which received 1 per cent pectin and physiologic saline solution without adrenal cortical extract.

e. Adrenal cortical extract plus serum. Seven dogs received 250 cubic centimeters of serum to which had been added 0.5 cubic centimeters of adrenal cortical extract per pound of body weight. This solution was administered intravenously before intestinal manipulation was started. The normal blood pressure was maintained for 30 minutes before a drop was noted. The decline in blood pressure from that point on was steady but gradual. It is apparent that the adrenal cortical extract delayed the 50 millimeter fall in blood pressure 36 minutes longer than in those dogs which received serum alone.

EXPERIMENT 6. In this group of experiments various agents were used in attempt to combat shock (Table II) induced by massage of the intestine over a period of 60 minutes. Four to 8 animals were used in each group. As noted in Table II, the average fall in blood pressure with 40 minutes of manipulation in control animals was 42 millimeters and with 60 minutes' manipulation was 58 millimeters, representing a fall similar to the controls in Experiment 1 (Table I). The experiments summarized in Table II reveal that 3 of the 4 substances used (i.e. pectin, adrenal cortical extract, and blood serum) delay the development of shock when intestinal manipulation is carried out. There is not a great deal of difference in the protective effect of the 3 substances although a mixture of adrenal cortical extract and serum appears to be more effective than any of the others. As in other groups of experiments, saline itself offers very little protective effect. In fact, when combined with other agents, it actually appeared to interfere with their protective action. We have no doubt that if serum were used in larger quantities, it would have proved more effective than any of the agents used.

INTRAVENOUS USE IN MAN

A solution of 0.75 per cent of pectin was used clinically in cases in which saline, blood or plasma would have been indicated. On the average, the solution was given at the rate of 500 cubic centimeters per hour; the largest quantity administered to one patient was 1500 cubic centimeters. The solution has been given clinically to 75 patients; a few had repeated infusions, and 1 patient had a history of bronchial asthma. Nine patients received the pectin during operations, and one while in shock due to hemorrhage. The clinical results are best illustrated in the following cases:

TABLE III.—PLASMA VOLUME CHANGES FOLLOWING INJECTION OF PECTIN AND SALINE SOLUTION

Patient	Initial plasma volume—c.c.	Amount injected—c.c.	Increase in plasma vol. 4 hrs. after infusion—c.c.	Hematocrit before and after
Pectin				
Mr. A. F.	2755	500	505	38–37
Mrs. M. L.	3260	500	500	37–37
Mr. F. B.	2250	500	650	36–36
Mrs. E. N.	2860	500	510	37–35
Mrs. H. D.	3500	500	500	38–36
Mr. H. C.	3800	500	575	37–38
Mr. C. K.	2025	500	537	37–37
Mrs. H. M.	2125	500	500	36–38
Mrs. L. N.	2900	500	600	36–38
Saline				
Mrs. H. B.	2875	500	150	38–38
Mrs. M. C.	2815	500	170	37–37

Average increase in plasma volume after pectin: 542 c.c. No change in hematocrit reading.
Average increase in plasma volume after saline: 160 c.c. No change in hematocrit reading.

TABLE IV.—BLOOD PRESSURE AND PULSE RATE CHANGES FOLLOWING INJECTION OF PECTIN

Patient	Average blood pressure before and after infusion		Average pulse rate before and after infusion	
Pectin				
Mr. H. T.	122/70	126/80	72	76
Mr. A. L.	122/70	122/70	72	76
Mrs. B. S.	170/90	170/90	72	72
Mrs. A. C.	120/70	126/80	80	84
Mrs. E. H.	130/70	134/80	84	88
Mrs. A. P.	130/70	136/80	92	96
Mr. A. F.	160/80	170/80	72	76
Mrs. M. L.	124/80	128/80	76	80
Mr. F. B.	122/80	126/80	72	76
Mrs. E. N.	90/60	110/70	96	84
Mrs. H. D.	122/70	126/80	76	76
Mr. H. C.	124/70	126/80	72	76
Mr. C. K.	130/70	136/80	72	76
Mrs. H. M.	110/70	110/70	72	72
Mrs. L. N.	110/70	120/80	72	76
Saline				
Mrs. H. B.	122/70	122/70	76	76
Mrs. M. C.	120/80	120/80	72	72

Average increase in blood pressure after pectin: systolic = 5 mm. Hg., diastolic = 6 mm. Hg.; average increase in pulse rate: 2 per minute.
No increase in blood pressure or pulse rate after saline.

CASE 1. S. G., a white male, weighing 150 pounds, was admitted to the emergency room of St. Elizabeth's Hospital, bleeding profusely from a stab wound in his right thigh. He had a tourniquet on his upper thigh, and he was cold, clammy, wet with perspiration, ashen-gray in color, thirsty, and his breathing was shallow. The pulse was 120 and of small volume; the blood pressure was 86/40. The diagnosis of shock was obvious. Unfortunately, no blood or plasma was immediately available. We decided to give him pectin solution while obtaining blood. He was given 1/6 grain morphine sulfate. The bleeding vessels were ligated and two sutures were used to approximate the skin. A prophylactic dose of tetanus antitoxin was administered. He was given 1500 cubic centimeters of 0.75 per cent pectin intravenously over a period of 2½ hours. His blood pressure rose to 124/76, the pulse rate was 72; the dizziness disappeared and he felt well. He went home the next day. No reaction was sustained.

To determine what effect pectin solution would have on the blood pressure during an operation, we gave the solution to the following patients:

CASE 2. T. W., a white male, weighing 165 pounds, was admitted to St. Elizabeth's Hospital, feeling nauseated and with a history of pain in the right side of his abdomen of 2 days' duration. His red and white cell counts were 4,800,000 and 7,800, respectively; hemoglobin, 85 per cent; his temperature was 99.2 degrees F., pulse rate, 84; and blood pressure 112/80. A diagnosis of recurrent appendicitis was made. He received 500 cubic centimeters of 0.75 per cent pectin solution during and after the operation. His blood pressure 2 hours after the operation was 120/80; he did not have any reaction.

CASE 3. J. B., a white male, 25 years old, weighing 170 pounds, was admitted to St. Elizabeth's Hospital with symptoms of acute appendicitis of 12 hours' duration. His temperature was 99.6 degrees F.; pulse rate, 92; and blood pressure 110/80. He had red and white cell counts of 5,500,000 and 12,000, respectively, with a differential count of 88 per cent polymorphonuclear cells and 22 per cent small lymphocytes. The hemoglobin was 95 per cent. He received 500 cubic centimeters of 0.75 per cent pectin during the operation and 500 cubic centimeters after the operation in 1 hour and 15 minutes. There was no reaction.

CASE 4. D. W., a white boy, 11 years old, weighing 108 pounds, was admitted to St. Elizabeth's Hospital, with a diagnosis of acute appendicitis. The laboratory examination revealed hemoglobin 85 per cent, red cell count of 4,500,000, white cells 16,150, with a differential count of 85 per cent polymorphonuclear cells and 15 per cent small lymphocytes. The blood pressure and pulse rate before operation was 110/80 and 88. He received 350 cubic centimeters of 0.75 per cent pectin solu-

tion. The blood pressure rose to 120/80. No reaction noted.

CASE 5. Mrs. L. McE., a white female, short, weighing 165 pounds, complained of gastric distress after meals. Previous x-ray examination revealed a nonconcentrating gall bladder containing stones. The laboratory examination revealed an icterus index of 10, red cell count of 3,800,000, white cells 12,500, polymorphonuclear 80 per cent, 20 per cent small lymphocytes, hemoglobin 80 per cent. The blood pressure before operation was 130/80. Her gall bladder was removed under cyclopropane anesthesia. She received 500 cubic centimeters of 0.75 per cent pectin during the operation, and 500 cubic centimeters after she returned to her room. The blood pressure 2 hours after the operation was 150/80. There was no immediate or late reaction.

PLASMA VOLUME STUDIES

In 9 normal individuals the plasma volume was computed according to the Evans blue dye method (6, 8, 13), using 5 cubic centimeters of 0.7 per cent solution, sterilized by autoclaving. Computation was made with the aid of a photoelectric colorimeter. The plasma volume was determined before and 4 hours after the administration of 500 cubic centimeters of 0.75 per cent pectin solution.

(Tables III and IV.) The average increase in plasma volume was 541.9 cubic centimeters. The plasma volume in 3 cases (Mr. H. C., Mrs. L. N., Mr. F. B.) still remained above the initial plasma volume 20 hours after the infusion (50 c.c., 70 c.c., 80 c.c. above, respectively).

Two patients (Mrs. H. B., Mrs. M. C.) received 500 cubic centimeters of physiologic saline solution and the plasma volume determined in the same manner as the patients who received pectin. In these individuals the plasma volume 4 hours after the infusion was 150 cubic centimeters and 170 cubic centimeters above the initial plasma volume. Although the amount of fluid injected was the same as that given to patients receiving pectin, the plasma volume increase in the same interval was much less than the quantity administered. (Table III). These findings correspond with the results obtained by Jacobson and Smyth (2), who found that after the infusion of 1000 cubic centimeters of physiologic saline solution, the plasma volume was definitely less than the amount given (a gain of only 350 cubic centimeters). In contrast, they did observe that pectin solution is retained in the circulation from 4 to 5 hours, and in some of their cases the plasma volume was still above the original, 24 hours after the infusion. We did not encounter any reactions that we could have attributed to the blue dye or the combination of the dye and the pectin solution.

The hematocrit readings in these patients remained about the same level (37–36).

SUMMARY AND CONCLUSIONS

Pectin is an economical substance for the preparation of colloidal solutions. It is nonantigenic, nontoxic, and is retained in the circulation longer than solutions of crystalloids.

It prevents the onset of shock in experimental animals for a longer time than when physiologic saline or isotonic glucose solutions are used alone.

It sustains the blood pressure well, as shown clinically in a patient in shock from hemorrhage, and in those who were undergoing operations.

The results obtained in these experiments indicate that pectin solutions may be used as a substitute for plasma or whole blood when these substances are not available.

In another set of experiments in which the fall of blood pressure was observed following 60 minutes' manipulation of intestines, various agents including pectin, adrenal cortical extract, serum, and physiologic saline (Table II) were used to see if they would inhibit the development of shock. Each of the first 3 mentioned exerted a protective influence, and to about an equal degree. We have no doubt that in larger doses serum would have been more effective than was any of the other solutions.

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STUDIES IN THE LYMPHATICS OF THE FEMALE URINARY BLADDER

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THE importance of the rôle played by the lymphatic system in medical and surgical diseases has now become well established. A thorough knowledge of the lymphatic circulation in the various organs of the body is often essential in translating the significance of pathologic changes. After a review of the medical literature, including modern textbooks on urology, one is convinced that little attention has been paid to the lymphatics of the human bladder. No attempt has been made to correlate the laboratory studies with urologic and pathologic problems. It is the hope in reporting these studies that the clinician's attention will be called to the importance of considering the lymphatics when he has occasion either to operate upon or to treat diseases of the bladder.

There is general agreement in the literature as to where the lymph collectors go after leaving the bladder wall. In fact, the location of the primary lymph nodes appears to have been the main object of most of the investigators. The location of these nodes, as reported by Parker, has been added to the composite drawings reported here merely to complete the lymphatic picture (Fig. 1). The purpose of this paper is to describe the lymphatics of the bladder itself. The posterior abdominal lymph nodes have received only secondary attention in this present study. From an extensive study of the lymphatics of a large group of human bladders *in situ*, it is believed that this knowledge may have clinical significance.

The lymphatics of the adult human bladder are difficult to inject; for this reason, infant cadavers were used exclusively. Dilute India ink was introduced into the bladder wall with a fine hypodermic needle. When a collecting lymph vessel became visualized the collector was followed by massaging or reinjecting until it ended either in another lymph vessel or a lymph node. This was carried out from every possible location of the bladder. Camera lucida sketches were made in approximately a dozen cases by the medical artist while the work was in progress. In a similar group of cases, the injected bladders were removed and prepared for study. Some were cleared by the Spalteholz technique, and all were preserved for careful study by the artist. By means of semidiagrammatic, composite drawings, it was possible to illustrate the important findings as they were interpreted.

GENERAL DESCRIPTION OF THE LYMPHATICS OF THE BLADDER

Lymph vessels originate in lymph capillary networks. When they are not supplied with valves their form remains relatively cylindrical. Usually after several larger cylindrical vessels unite the terminal collector is seen to contain valves. The form of the vessel then becomes beaded, that is, alternately constricted and dilated. As the beaded collector becomes larger the number of valves diminishes; that is, the distance between the valves becomes greater as the diameter of the vessel becomes larger. The courses of the lymph vessels are particularly tortuous in the blad-

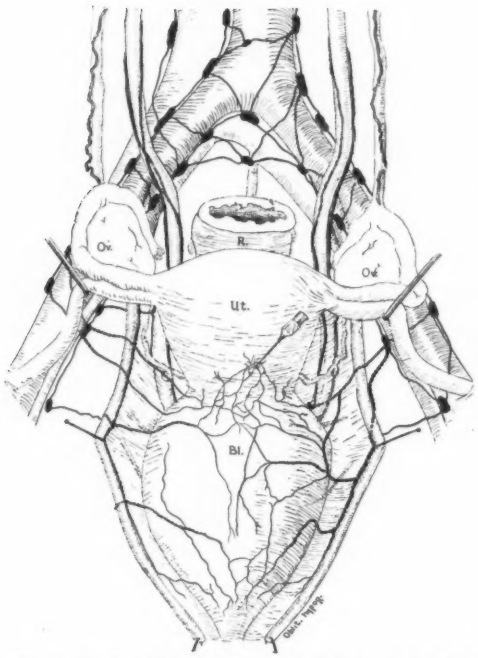

Fig. 1. Regional lymph collectors and nodes of the bladder. Note the close relation of the main collectors with the uterine, vaginal and hypogastric vessels as well as the ureter and cervix of the uterus.

der. This is due in part to the elasticity of a large part of the organ.

Attempts to inject the mucosa in many human and animal bladders were without success. Anesthetized dogs were used in an effort to inject the material into the mucosa so that a lymphatic network could be verified; a definite lymphatic network in the mucosa could not be demonstrated. Perhaps there are lymph spaces that open directly into the adventitia of the submucosa. In the submucosa, the network could be demonstrated. The lymphatic ducts began here and ran as small collectors in a staircase fashion immediately to the external surface and joined the collectors running along in the adventitia covering the bladder. In the area which is covered by the peritoneum, the collectors received lymphatic capillaries from this overlying membrane.

The direction of the lymph stream is normally determined by the valves within the lymph vessel. In those collectors that have no valves, retrograde flow may take place if the main channel becomes obstructed. It is even possible to produce retrograde flow for a short distance in the beaded collectors if the obstruction is complete and persists for a long time in the live experimental animal. A heavy metal, thorium dioxide, known to have a tendency to plug the smaller lymphatic vessels was utilized in the study of this subject. Three live dogs were operated upon and their bladders were injected in various places with this radio-opaque material. In 2 dogs, all the large vessels were ligated. These animals were followed for 3 to 6 months by clinical observation and x-ray films before being subjected to autopsy. There was evidence of lymphatic blockage and retrograde edema in the tissues. Colin, Lee, and Gabrielle, working on the lymphatics of animals in other portions of the body, also reported evidence of retrograde lymphatic edema. Braithwaite, and more recently, Rouviere, demonstrated experimentally that lymph nodes attacked by inflammation act as an obstruction. The lymph vessel dilates above the obstacle, and backflow may become established in the unbeaded ducts, or else an edema persists.

The inconstant small lymph nodules, usually found along the sides of the obliterated hypogastric vessels, are not considered primary lymph glands. Occasionally these may be found on the anterior bladder wall and in the prevesical space. These tiny glands are regarded as intercalated (interposed) lymph nodules, that is, minute lymph elements interrupting a collector on its way to its primary echelon. These minute elements are not common and in most specimens not seen.

COURSE OF COLLECTORS

The lymphatic collectors in the anterior wall of the bladder will be described separately from those of the posterior wall. The trigone, floor, and inferolateral walls up to the level of the obliterated hypogastric vessels are included in the description of the posterior wall. For purposes of description, these divisions, that is, the anterior and posterior walls, are further divided into upper, middle, and lower thirds.

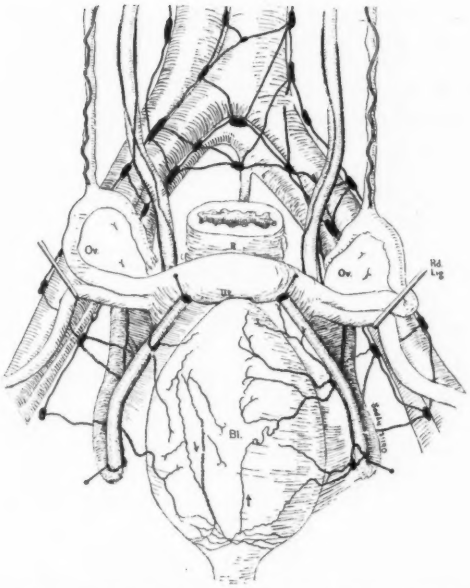

Fig. 2. The position of the main lymph collectors of the anterior bladder wall as usually found are represented by those shown on the right side of the organ. An important variation is represented by the course taken by those on the left side.

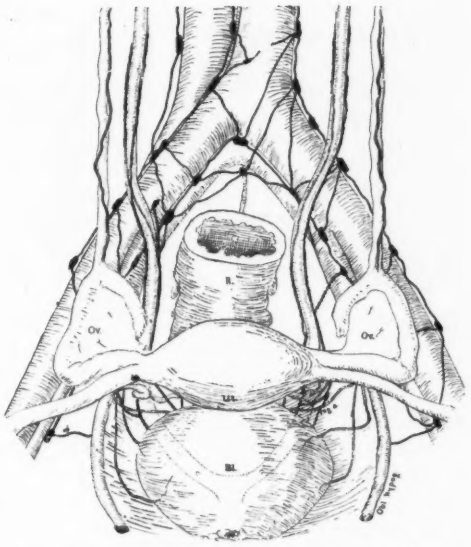

Fig. 3. Composite semidiagrammatic sketch of the collectors of the posterior bladder wall. Note the fine network marked out of the injection mass being introduced into the lower segment of the uterus.

Anterior wall. When the material was injected in the upper third, fine lymphatic trunks were seen to arise and proceed downward and laterally toward the middle third where they usually turned more directly laterally and joined trunks coming from the middle third. In some instances, trunks passed directly laterally, joined similar trunks, and proceeded down beside or behind the obliterated hypogastric artery. Occasionally one began in the uppermost portion on either side of the midline. This ran along with or without a smaller satellite, proceeding directly downward to the lower third in the prevesical space. There it often turned abruptly laterally and formed a network of vessels, and then ran slightly upward to join the main collectors parallel with the obliterated hypogastric.

The main lymphatic ducts of the anterior wall appeared to arise from the middle third. They ran more laterally but great variations were to be seen. There was definite evidence to support Arguello-Cervantes' contention of there being relatively little anastomosis of the lymph vessels on one side of the median line of the anterior wall with those on the opposite side. The lymphatic collectors usually fused and formed one large beaded vessel that received the ducts coming from the upper and lower thirds. This large collector occasionally passed through an intercalated node and proceeded down the lateral wall beside the obliterated hypogastric vessel, receiving trunks from the posterior wall and finally passed laterally, close to the origin of the ureter. In many instances, it was seen to ascend as single or multiple collectors on one or both sides of the ureter and at various levels to turn laterally to join primary nodes. Frequently they crossed the uterine artery and proceeded to the level of the brim of the pelvis before leaving the ureter (Fig. 2).

In the prevesical space, there was a network of fine lymphatic vessels which had a definite connection with the entire neck of the bladder, posterior vagina, and cervix of the uterus. If injection was done in the outer muscular wall of the lower portion of the uterus and cervix,

the dye ascended in a retrograde manner through the network of the vessels under the trigone and on each side of the neck of the bladder and filled the network in the prevesical space. This network was connected with trunks which ran up laterally on each side and joined the main beaded collectors which drained the upper and middle thirds of the anterior and posterior walls of the bladder. Rarely a retrograde injection proceeded from the lower third directly up to the upper third of the bladder.

Posterior wall. When the injecting material was placed on one side or the other in the upper third the lymphatic network was seen to cross freely from one side to the other, forming definite and intimate anastomosis and uniting the trunks from both sides of the midline. The trunks were relatively more numerous and were generally easier to inject and follow. This was partially explained by the fixation of a large part of the posterior wall. The paths of the trunks were not so constant as those of the anterior wall. The individual trunks frequently coursed laterally to the primary nodes without uniting with trunks coming from other portions of the bladder. In some specimens, the trunks appeared to be more or less independent of the vessels of the middle third and joined the trunks coming from the upper and middle thirds of the anterior wall. The posterior trunks of the upper third were more intimately connected with those of the anterior bladder wall than were those of either the middle or lower thirds.

In the middle third of the posterior wall, the arrangement of the trunks was similar to that of the upper third except there were generally larger trunks and this portion had a more definite connection with the rich network over the trigone in the lower third. These trunks joined those of the anterior wall less often than those of the upper third.

In the lower third, over the trigone, the vessels were more numerous, and many individual trunks coursed separately to the primary nodes (Fig. 3).

CONCLUSIONS

1. The study of the lymphatics of the human urinary bladder convinces one that a thorough knowledge of this system is of definite clinical importance.

2. This anatomical feature should be studied not only by the urologist who may treat diseases of the bladder but by any surgeon who operates upon the lower abdomen or pelvic organs, particularly of the female.

3. The lymphatic network begins in the submucosa where the tiny ducts run directly to the external surface and there join large collectors containing valves.

4. The valved collectors determine the course the lymph flows. Retrograde and collateral circulation may obviously be more difficult in these beaded (valved) vessels which often form the main trunks.

5. As a general rule, the lymph system of the anterior wall of the bladder is drained by collectors on either side of the midline that fuse and form one large beaded vessel. These run down along the course of the obliterated hypogastrics on either side toward the neck of the bladder near the origin of the ureter. There they turn laterally after receiving trunks from the posterior wall and then join primary lymph nodes.

6. There is an occasional specimen in which the main trunk, instead of coursing along the side, runs more nearly over the dome but usually to the side of the midline.

7. There is relatively little anastomosis of the lymph vessels from one side of the median line of the anterior wall with those on the opposite side.

8. There is a large network of small (unbeaded) lymph ducts completely surrounding the neck of the bladder which are intimately connected with those of the posterior wall of this organ as well as the cervix of the uterus.

9. The collectors of the posterior bladder wall, unlike those of the anterior wall, usually leave the bladder separately to course to the regional nodes.

10. Over the floor, or the posterior wall, of the bladder, there is abundant anastomosis of the fine lymphatic network of one side of the median line with those of the opposite side.

11. The posterior abdominal lymph nodes receive the lymphatics from the bladder and other pelvic organs.

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THE Rh FACTOR IN INTRAGROUP BLOOD TRANSFUSION REACTIONS

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THIS report concerns an Rh negative obstetrical patient who carried a dead fetus for 2 months and who then at the middle of the 7th month of pregnancy aborted a macerated stillbirth. Following the abortion, because of uncontrollable uterine hemorrhage, the patient went into shock. One hundred cubic centimeters of group o, Rh positive blood was administered. A severe hemolytic transfusion reaction occurred and was followed ten days later by generalized convulsions. The patient gradually recovered.

Twenty-five similar cases have been analyzed and are presented briefly.

The Rh factor has been shown to have an important part in at least four hitherto unexplained processes. These are the occurrence of hemolytic transfusion accidents after repeated transfusions with blood of the homologous group (26); the occurrence of similar reactions after the first transfusion in obstetrical patients (28, 31); the frequent occurrence of complications of pregnancy in women with erythroblastotic fetuses (24, 29); and the uniting of universal edema of the fetus, icterus gravis neonatorum, and anemia of the newborn under the one disease entity, erythroblastosis fetalis (17, 24, 28). The fundamental mechanism in all of these processes is the isoimmunization of an Rh negative individual to Rh agglutinogens. The introduction of the agglutinogens may take place either by transfusion of Rh positive blood into an Rh negative individual or by the presence of an Rh positive fetus in an Rh negative mother. When the anti-Rh agglutinins have reached a high titer as the result of isoimmunization, they may react with the introduced agglutinogens. If the introduction is by transfusion, a hemolytic reaction may occur. In the case of a pregnant woman, she may deliver an erythroblastotic infant or abort an erythroblastotic fetus. Further details concerning the Rh factor may be found in recent reviews (9, 23, 40, 46).

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CASE REPORT

The patient was a 36 year old Irish housewife, decigravida, quintipara (4 living children: 4 spontaneous abortions). The last 2 pregnancies yielded term babies. The next to last baby is living and well, the last died 5 hours postpartum (cause unknown). The patient was registered in the antepartum clinic of the Sloane Hospital for Women on October 28, 1942. Physical examination showed no significant defects. Her last menstrual period was August 7, 1942; the estimated date of labor was May 14, 1943. The blood pressure was 125/70; the urine, normal. Her blood was group o and Rh negative. A tendency to excessive weight gain was noted in December and was corrected with a 1200 calorie diet. In January, fetal movements ceased, and a diagnosis of fetal death was made. This was substantiated by x-ray. Thereafter, the uterine size receded slightly, and no further weight gain occurred. Throughout the remainder of the pregnancy, the blood pressure averaged about 140/80; a faint trace of albumin appeared in the urine at the last clinic visit, March 29. On March 30, the patient was admitted in active labor and delivered precipitously while being transferred from the wheelchair to the bed. The fetus was a macerated stillbirth of 5 months' size. The placenta was intact and fibrotic; the membranes were questionably intact. Continuous uterine bleeding occurred which could not be controlled by uterine massage, pituitrin, and ergonovine. Examination showed the cervix to be intact and no material could be felt inside the uterus. The uterine cavity was packed tightly with iodoform gauze.

The blood pressure by this time had fallen to 75/40, and the patient was in mild shock. A plasma transfusion was started immediately and was followed by a transfusion of group o blood compatible by the usual method of cross matching. This blood was Rh positive. One hundred cubic centimeters had been administered before examination of the patient's old chart revealed her to be Rh negative. The blood was stopped immediately and the plasma was continued. The patient's condition gradually improved with the blood pressure rising to 130/60.

Forty minutes after discontinuing the blood transfusion, the patient had a shaking chill lasting 20 minutes. Following the plasma, she received 500 cubic centimeters group O, Rh negative blood.

Six hours after the transfusion, the patient was returned to the ward, out of shock but still bleeding. She complained of backache and of severe headache. During the night, she slept at intervals and the uterine hemorrhage gradually ceased. She voided first 350 cubic centimeters and then 200 cubic centimeters of bloody urine. The next morning, the patient was alert and felt well; however, two different samples of blood taken for hematocrit exhibited hemolysis and showed the percentage of red blood cells to be 25.7. When she failed to void for 8 hours, she was catheterized and 90 cubic centimeters of dark brown granular urine was obtained. Since the urinary *p*H was 4.5, alkalization was started and a total of 45 grams of sodium bicarbonate was given in divided doses every 4 hours by mouth and by rectum. At the end of 20 hours, the urinary *p*H was 8.0. Because of low urinary output, fluid intake was restricted to approximately 2 liters per day to maintain an adequate fluid balance.

On the 3d posttransfusion day, the patient was lethargic and complained of severe occipital headache. She was nauseated and vomited frequently. There was an icteric tint to her skin and slight edema of her hands, face, and neck. The liver was tender and could be palpated 3 centimeters below the costal margin. On the 4th day, the patient was more alert and cheerful. She complained, however, of right flank pain. Examination revealed tenderness and questionable enlargement of the right kidney. In addition, a small mass was found in the right upper quadrant which was interpreted as being due to enlargement of the gall bladder. Blood specimens for hematocrit no longer showed hemolysis. Between the 2d and 7th days, because of extreme oliguria, urinary specimens were obtained by catheterization. During this period, there was little change in her general condition although by the 7th day the nausea, vomiting, and headache had diminished. The liver, however, had enlarged to 8 centimeters below the right costal margin.

On the 9th posttransfusion day, the urinary output rose sharply. The blood pressure had also risen suddenly to 175/100. She had difficulty in keeping awake and complained of a severe occipital headache.

Early the next morning (10th posttransfusion day) after passing 800 cubic centimeters of urine during the night, she complained of blurred vision and occipital headache. She vomited frequently. Without warning, she had three epileptoid (or eclamptoid) convulsions at about 15 minute intervals. Each lasted for approximately 1 minute. These convulsions were characterized by a glassy stare followed by an increase in the rate and depth of breathing, tonic and clonic spasms of the extremities, rapid blinking of the eyelids, copious frothing at the mouth, and cyanosis. Immediately after the first attack she responded to questions but was unable to see. At this time, the retinae showed only narrowing of the arterioles. The blood pressure was 220/110. The breath was not uriniferous. Six similar convulsions occurred during the remainder of the morning, one of which lasted 5 minutes. Immediately after each convulsion, she was given 20 cubic centimeters of a 10 per cent solution of magnesium sulfate and 50 cubic centimeters of a 50 per cent solution of glucose intravenously. These injections, especially at first, were followed by brief periods of semiconsciousness. At other times she was comatose. By midday, the blood chemistry report was available. The carbon dioxide combining power was 15.8 milliequivalents per liter. There had been a rapid concentration of her blood during the past 48 hours as evidenced by an 18 per cent increase in hematocrit and 27 per cent rise in plasma proteins. Because of the acidosis and this hemoconcentration, she was given 200 cubic centimeters of a 5 per cent solution of sodium chloride and 20 cubic centimeters of eschatin[1] (500 dog units).

During the next 2 hour period, she had 3 less severe convulsions; the last one consisting only of generalized muscular twitching. Throughout most of the time the blood pressure averaged 170/105 without significant change. It is of interest that the urinary output, which had become established at a satisfactory level prior to the onset of convulsions, did not diminish during the latter period but actually increased. She had no more convulsions and the next day was able to recognize those around her. Her speech was thick, but neurological examination was otherwise negative. The patient's course then became one of gradual improvement. The liver was no longer palpable. The blood pressure reached normal by the 17th day, and she was discharged in good condition on the 33d day after the abortion and transfusion.

CHEMICAL CHANGES

The changes in the blood chemistry are given in tabular form and also graphically plotted as per cent change from normal (Table 1, Fig. 1).

Hematocrit. Within 24 hours following the transfusion, the hematocrit fell from 41.5 per cent to 25.7 per cent in spite of having received 500 cubic centimeters of Rh negative blood. During the next 4 days, the cell volume continued to be low despite 3 more transfusions of Rh negative blood. This fall in hematocrit is characteristic of a severe hemolytic process.

Plasma proteins. The total proteins decreased from 6.12 grams per cent to 5.27 grams per cent on the second day after the reaction.

[1]Eschatin is a highly purified extract of the adrenal cortex (Parke Davis).

TABLE I.—CHANGES IN BLOOD CHEMISTRY

		Hematocrit (per cent)	Total proteins* (grams per cent)	Sodium*	Chlorides*	Carbon dioxide combining power†	Potassium*	Nonprotein (nitrogen) (mg. per cent)
				(millequivalents per liter)				
Normal values		41.0	7.0	142.0	103.0	27.0	4.40	20—35
Days	Time							
1	1:00 pm	41.5§	6.12					
2	11:40 am	25.7	5.78					
3	2:00 pm	23.7	5.34					69.2
	8:00 am	22.2	5.27			31.9		80.7
4	8:30 am	23.4	5.68	142.8		35.7		90.0
5	9:25 am	28.6	5.65	138.6		32.6		97.5
6	10:00 am	27.7	5.31					
7	10:00 am	30.0	5.82			25.9		110.0
8	9:30 am	31.0	5.75			24.6		114.0
9	10:30 am	32.3	6.29	147.0		24.1		118.0
10	7:00 am	37.5	7.21	147.6	98.3	13.4	4.43	126.0
	9:25 am	38.3	7.62	148.5	99.0	15.8	5.19	130.0
	1:45 pm					9.6		127.0
	4:30 pm	41.3	7.48	152.2	105.1		4.83	
11	8:30 am	40.0	7.72	154.4		24.1		129.0
12	8:15 am	36.9	6.97	136.0	92.7	24.5	4.60	115.0
13	9:30 am	39.4	7.28	141.5	91.9	26.3	4.91	118.0
14	9:00 am	36.3	7.31	143.3	96.9	27.7	4.63	106.0
15	8:00 am		7.18			27.2		97.8
16	9:00 am	36.3	7.58					
17	9:45 am	36.3	8.03					
18	7:30 am	38.3	8.20			21.9		100.0
21	8:00 am					22.7		87.6
24	11:00 am	31.6	7.11			24.1		66.2

All determinations were done on venous blood
*Plasma
†Serum
All hematocrits were centrifuged for one hour except the origina determination

This occurred in spite of 1,100 cubic centimeters of plasma and 900 cubic centimeters of blood. From this point, the proteins increased and reached 8.2 grams per cent on the 18th day. In all the patient received 3,700 cubic centimeters of plasma and 1,900 cubic centimeters of Rh negative blood, roughly equivalent to 19 donors.

Plasma sodium. On the 3d day following the transfusion reaction, the plasma sodium was normal, 142.8 milliequivalents per liter. By the next morning, it had decreased by 4.2 milliequivalents per liter. The values on the day of the convulsions rose from 147.6 to 152.2 milliequivalents per liter following the hypertonic salt and adrenal cortical extract. By the next morning, this had increased still further to 154.4 milliequivalents per liter following which a decline occurred.

Plasma potassium. The venous blood taken after the 4th convulsion revealed the plasma potassium to be 4.4 milliequivalents per liter. After the 7th convulsion, this had increased to 5.19 milliequivalents per liter. After the hypertonic salt and adrenal cortical extract, a level of 4.83 milliequivalents per liter was obtained. Three subsequent determinations on the 2d, 3d, and 4th days following the convulsions showed the concentration to be lower than the peak value but higher than the initial determination.

Plasma chlorides. The chlorides rose from 98.3 milliequivalents per liter taken after the 4th convulsion to 105.1 milliequivalents per liter following the administration of hypertonic salt. On the 3d day after the convulsions (13th posttransfusion day), the plasma chloride concentration was 91.9 milliequivalents per liter. Twenty-four hour urine specimens were then analyzed for sodium chloride. The first such specimen contained 13.5 grams sodium chloride in 4 liters of urine. She was then started on enteric coated sodium chloride pills, 1 gram every 4 hours.

Carbon dioxide combining power. This showed the greatest fluctuation of any electrolyte. The first determination done 2 days after the transfusion reaction and after alkalization revealed a value of 31.9 milliequivalents per liter. By the next day, this had risen to 35.7 milliequivalents per liter. From this point on, there was an increasing acidosis as shown by a fall to 13.4 milliequivalents per liter after the 4th convulsion. This condition was apparently corrected as judged by a return to normal during the succeeding days.

Nonprotein nitrogen. The nitrogen retention was manifest by a value of 69.2 milligrams per cent on the day following the transfusion reaction. This progressively increased, reaching 130 milligrams per cent after the 7th convulsion. From then on, the values fell slowly to 66.2 milligrams per cent on the 23d day following the giving of Rh positive blood.

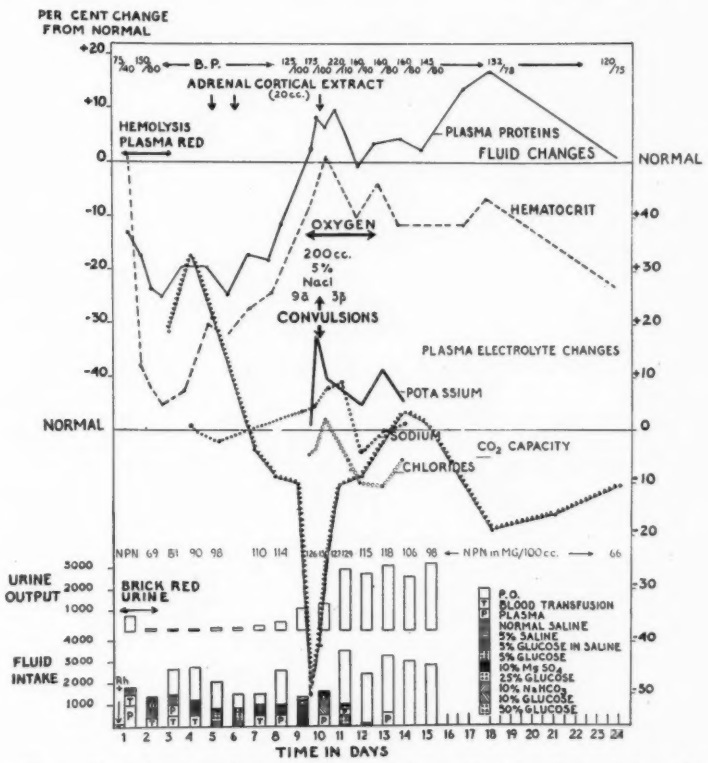

Fig. 1. Blood chemistry changes in Rh transfusion accident described—decigravida, quintipara, missed late abortion.

Creatinine. At the height of the acidemia, the creatinine value was 12.5 milligrams per cent.

Cephalin flocculation test was 2+ the day after convulsions and negative 18 days later.

Urine changes. The dark granular urine of the first two days became red and clearer as the pH became greater than 7.0. The albuminuria progressed from a very faint trace to the peak on the 5th day of 40 per cent (40 per cent of the test tube was filled with solid albumin after boiling, addition of acid, and waiting 1 hour) and then disappeared. The hemoglobinuria cleared by the 6th day, and no red blood cells were found in the urine on discharge.

SIMILAR SELECTED CASES FROM THE LITERATURE

Twenty-five cases similar to the one presented have been tabulated in chart form (Table II). These are reports of women with abnormal obstetrical histories who have been transfused with blood of the same group because of hemorrhage and who subsequently developed hemolytic reactions. Their ages fell predominately in the decade 30 to 40. Their gravidity was generally higher than their parity; in their past obstetrical histories, there were many instances of spontaneous abortions, macerated stillbirths, and erythroblastotic fetuses. Toxemia of pregnancy was common. The transfusions were generally necessitated by postpartum or postabortal hemorrhage. In most cases, the donor's blood was reported as compatible by routine cross matching. Unwittingly, in 50 per cent of the cases the husband was the selected donor. In 12 cases verification of the cross matching after the transfusion reaction showed

TABLE II.—INTRAGROUP AND Rh TRANSFUSION REACTIONS

	Reference	3	38	34	25	25	45	41	39	21	21	15	32	31	4	8	14	11	11	11	11	30	35	1	1	18	EL
Obstetrics	Age	49	36	27	33	22	32	24	32	25	24		38	25	30	30	25	32	30	32	38	37	30	26	29	36	36
	Para	4	0	0	6	3	3	5	3				4	3		3	2	2	2	3	2	8	3	3	1	4	5
	Grava	5	1	4	7	4	4	6	5				4	3		4	2	4	2	3	3	12	4	3	4	4	10
	Toxemia	+							+				+	+					+		+	+	+	+			+
	Abortion	+	+	+	+	+		+		+				+	+				+				+		+		+
	Erythroblastosis Fetalis													?+			+	?+	+	+	+	+		+			?+
	Living Child								+				+			+						+					
	Secondary Hemorrhage	+	+	+	+	+		+		+	+		+	+	+	+	+				+		+	+			+
	Shock		+	+	+	+		+			+		+		+	+		+									+
Transfusion	Amount	400	500	400	420	500	750	500	400	500	500	500	500		60	500	600	1750	1075	1250	1100	150	750	500	500	500	100
	Cross-matched	+	+	+	+	+	+	+	+A			+	+		+	+	+	+	+			+A	+	+		+	+
	Blood group		O	O			A	O	A	O	O	O	A	O		O	A	A	O			A		O	A	O	O
	Donor	D	H	H	H	D	D	H	H	H	H	H	D	H	D	D	D	H	D	H	H	D	D	D	D	D	D
	Rh patient																	−	−	−	−			−	−	−	−
	Rh donor																	+	+	+	+			+	+	+	+
	Rechecked		N	N	N			N	N		C	N		N	C	C	C					N					N
Reaction	Time min.—c.c.	Im	O	Im	20	30	420	90	Im	90	Im	Im	O	10	Im	90	35		30	60		Im		O	Im		40
	Lumbar pain	+	+		+		+			+					+								+				+
	Chill and fever	+			+	+	+	+	+	+	+	+		+		+	+	+	+	+		+	+		+		+
	Vomiting	+		+	+	+	+	+		+					+		+						+				+
Renal Shutdown	Oliguria	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	?+	+	+
	Hemoglobinuria	O	+	+	+	+?	+?	+		+		+	+	+	+				+			+		+	+		+
	Alkalization		+										+			+				+		+					+
	Diuresis-Day	9			4	10	5		7	14	7		4		10	6	5			11	7		8			2	9
Course	Urea nitrogen	71	175				75		282								170				82						
	Nonprotein nitrogen				92	120		180		180	150	235	262							350			165				130
	On day	7	3		11	8	13	12	8	11	18		13				13			16	7						11
	Edema							+		+			+		+		+			+							+
	Jaundice		+					+	+	+	+		+				+	+	+							+	+
	Convulsions	T	U		+	T	+	T					T				U										+
	Hypertension					+	+						+				+						+	+			+
	On day					16	6						4				6										10
	Treatment	DD				SA	VS																UD	SB			
	Recovery	+			+		+	+	+	+	+	+	+	+	+	+	+			+	+	+	+	+	+	+	+
	Death on day		8	1		18												9	10								
	Autopsy		+			+													+								

Key: *EL* = case presented; cross-matched = *A* = agglutinated; donor = *D* = professional, *H* = husband; rechecked = *N* = not compatible, *C* = compatible; time = *Im.* = immediate, Figures = minutes after transfusion; convulsion = *U* = uremia, *T* = muscular twitching; treatment = *DD* = bilateral decapsulation, *SA* = spinal anesthesia, *VS* = venisection and saline, *UD* = unilateral decapsulation, *SB* = splanchnic block.

agglutination or hemolysis of donor's cells in 8 and compatibility in 4. In 7 cases, the donor was proven Rh positive and the recipient Rh negative.

The reaction occurred during the transfusion in 8 instances or within 1½ hours after the transfusion. Chill and fever were recorded in 18 instances, vomiting in 10, and lumbar pain in 7. Among the late manifestations, oliguria was constant in all 25 cases. Hemoglobinuria was noticed in 12. In 10 cases, jaundice was reported. Eight patients developed convulsions. Edema and hypertension were noted 6 times. Dyspnea and cyanosis were frequent early manifestations. Bloody and dark urine was usually passed within a short time; there was rapid progression to oliguria and anuria in 3 fatal cases. In 4 cases, shown in Table II, (14, 25, 32, 45) the triad—diuresis, hypertension, muscular twitching or frank convulsions—occurred in sequence; but, in the others, the appearance of diuresis was a turn toward recovery. There were 5 deaths in these 25 cases. The earliest occurred on the first day and the latest on the eighteenth.

It is also of interest to note that the pathology of the kidneys in fatal transfusion reactions is very similar to that found in crush injury cases with anuria (13); in both, there are similar pigment casts in the distal convoluted and collecting tubules and catarrhal changes throughout the nephron. In the crush injury cases of Bywaters (12), the clinical symptoms and chemical changes are strikingly similar to those in the case presented. These patients also went into shock, and following the treatment of shock by transfusions of whole blood or plasma, developed oliguria, edema, vomiting, hypertension, elevated nonprotein nitrogen, increase in creatinine, and hyperpotassemia.

Van Slyke, Phillips, Hamilton, Archibald, Dole and Emerson (personal communication) have produced in dogs a similar syndrome and changes in renal histology by producing hemorrhagic shock, and reinjecting part of the withdrawn blood after laking its cells.

ANALYSIS OF STUDY

The majority of intragroup transfusion accidents occurring in pregnant or postpartum patients are due to Rh incompatibility. There is little doubt of its importance in the case presented; for the father, all 4 of the living children, and presumably the aborted macerated stillbirth are all Rh positive. The mother's blood taken before the transfusion was Rh negative. Actual determinations of the anti-Rh agglutinins done by Dr. Philip Levine (27) 2 weeks after the reaction demonstrated that it was anti-Rh^1, in specificity, that it had a very strong anti-Rh_1 titer of about 1:160–1:320, and that the anti-Rh was moderately active with a titer of about 1:40. This high titer may be the result of an especially activated process of isoimmunization which was due to the "dead fetus serving as an antigenic stimulus" (31) plus the transfusion. Thus because of the high titer of anti-Rh agglutinins, the introduction of a relatively small amount of agglutinogen (100 c.c. of Rh positive blood) precipitated a severe hemolytic reaction.

Since the occurrence of this near-catastrophe, it has become the established policy of the

No._____

Date_____ City No._____ Unit No._____

Name_____ Private_____ Semiprivate_____

Age_____ Color_____ Floor_____ Ward_____

Diagnosis _____

Indication for transfusion _____

Emergency — Yes_____ No_____

Last R.B.C., Hgb., Hematocrit_____ Date_____

Group_____ Amount required_____ ml.

When wanted? Date_____ Time_____

Has patient's blood been sent to bank? Yes_____ No_____

Has patient been transfused before? Yes_____ No_____

Any transfusion reactions? Yes_____ No_____

Previous pertinent obstetrical history:

abortions____ stillbirths____ neonatal deaths____

erythroblastosis fetalis____ icterus gravis____

Has Rh been done? Yes_____ No_____ Rh +_____ Rh -_____

Has patient sent in donors? Yes_____ No_____

Signed_____
(Attending's or Resident's signature if no donors)

Telephone requests can not be taken. Requisitions incompletely filled out can not be honored.

Fig. 2. Requisition form for blood transfusions used at Presbyterian Hospital. Includes questions relative to Rh factor, previous transfusion reactions, and pertinent obstetrical history.

Sloane Hospital for Women that no obstetrical patient shall be transfused with blood of unknown Rh unless the patient's Rh is known. In the event that she is Rh negative, Rh negative blood is used for transfusion. When emergency transfusion is required and the patient's Rh has not been determined, only Rh negative blood is used. When Rh negative blood is not available in either of these latter instances, plasma transfusions are employed.

What should be done when such a hemolytic reaction occurs?

1. Stop the transfusion immediately, and, if the patient's condition requires it, a plasma or serum transfusion should be substituted.

2. Prove that a hemolytic reaction has occurred by drawing and centrifuging the blood and examining the plasma for hemolysis. Test the patient's and donor's blood for Rh factor.

3. Secure compatible Rh negative blood to support the circulation as indicated.

4. Catheterize the patient 1 hour after the first appearance of the reaction, and examine the urine for hemoglobin, red blood cells, and pH.

5. Start alkalization immediately. This is accomplished by the administration of 4.0 grams of sodium bicarbonate by mouth every 4 hours and a 4 per cent solution of sodium bicarbonate by rectal tap every 4 hours. A 1/6 molar sodium lactate solution may be used intravenously. Alkalization should be continued to maintain the urinary pH above 7.0.

6. Analyze the blood for hematocrit and non-protein nitrogen, and the plasma for chlorides, carbon dioxide combining power, and proteins daily.

7. Restore the cell volume and plasma proteins by giving Rh negative blood and plasma transfusions.

8. With the occurrence of oliguria, *restrict* the fluid intake to between 2,000 and 3,000 cubic centimeters daily to prevent overhydration.

9. If convulsions occur in association with increasing hemoconcentration and acidosis, extra sodium may be administered in the form of hypertonic saline.[1] Eschatin may help by causing sodium retention and potassium diuresis.

It is emphasized that the treatment of conditions such as this should not be empirical but rather directed toward correcting the acidosis, maintaining fluid and electrolyte balance, and restoring cell volume and plasma proteins.

At the time of the hemolytic reaction, there is a lysis of not only the administered donor's blood, but also the patient's own red blood cells. This is attributed primarily to an agglutinin and agglutinogen reaction. With this process, there is liberation of the various intracorpuscular constituents following which hemoglobinuria and oliguria become evident. The mechanisms involved have not been adequately explained although there are adherents to both the theories of tubular blockage by hematin casts and of renal arteriolar vasoconstriction. Whatever may be the basis, the oliguria in the case presented was severe and protracted and was not prevented by either prompt alkalization (16) or immediate compatible blood transfusion (19); and did not give way to diuresis until after the hemoglobinuria cleared. A few hours following the onset of diuresis, the patient entered a critical phase marked by repeated generalized convulsions and coma.

The cause of the convulsions is difficult to explain. They may be associated with changes in the electrolytes secondary to the oliguria. Prior to the onset of convulsions, there had been a rapid increase in hemoconcentration. When they occurred the patient was in acidosis, the nonprotein nitrogen was near its peak, and the chlorides were below normal. As the convulsions progressed, there was a greater increase in the potassium than in the sodium concentration.

The convulsive action of potassium is known (6, 7, 20, 22). In one of our dogs dying in convulsions following the injection of potassium salts, the cerebrospinal fluid concentration of this cation was 13.2 milliequivalents per liter and in another 13 milliequivalents per liter (36, 37).

This patient was given hypertonic saline intravenously as such solutions cause reduction in brain volume and dilution of the blood. Fur-

[1] This would not be of any immediate help to the acidosis. It would seem logical to use injections of sodium chloride *plus* sodium bicarbonate, or, in severe acidosis, of sodium bicarbonate alone, as in cholera. In the case reported, about 4 liters of isotonic sodium bicarbonate solution would have been required to raise the plasma carbon dioxide from the level of 9 milliequivalents to normal.—Van Slyke.

ther, sodium salts are known to protect against lethal doses of potassium in animals and to lower the level of potassium in the blood (2, 5, 10).

Adrenal cortical extract has been shown to have a similar action (33, 42, 43, 44, 47). It was used here in conjunction with salt.

One is not justified in attributing the subsequent favorable course to this therapy alone. However, the convulsions decreased in severity and ceased. Blood dilution was secured, blood potassium fell, the concentration of sodium rose, and the acidosis was corrected. The data are incomplete. In the future more studies should be carried out in similar cases before any definite conclusions can be drawn.

To obviate such transfusion reactions, a requisition form for blood transfusions has been introduced in the Presbyterian Hospital. This form embodies questions relative to the Rh factor, previous transfusion reactions, and pertinent obstetrical history (Fig. 2).

SUMMARY

A case is presented in which an Rh negative obstetrical patient sustained a severe transfusion reaction following 100 cubic centimeters of Rh positive blood. The reaction was characterized by chill and fever, hemoglobinuria, jaundice, oliguria, and convulsions. The blood chemical findings are tabulated. Twenty-five similar cases of intragroup transfusion reactions have been selected from the literature. A rational, although tentative, method of therapy is outlined. It is emphasized that under no circumstances should obstetrical patients be transfused with Rh positive blood unless the patients have been tested for the Rh factor.

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EXPERIMENTAL HEAD INJURY WITH SPECIAL REFERENCE TO CERTAIN CHEMICAL FACTORS IN ACUTE TRAUMA

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THE oxidative metabolism of the brain in head injury is a subject which requires further investigation. Clinical observations suggesting the occurrence of cerebral anoxia and possible factors in its causation following craniocerebral injury have been discussed by Schreiber. Schnedorf and associates noted a decrease in the oxygen saturation of the arterial blood in 8 of 9 dogs subjected to experimental head injury and found low arterial blood oxygen in 10 of 12 patients with concussion of the brain. Lindquist and LeRoy studied the cerebral blood flow in the dog by means of a thermostromuhr placed on the right common carotid artery, the right external and the left internal carotid arteries being ligated and the vertebral vessels left intact. A decrease in cerebral blood flow was observed following head injury, and determinations of the oxygen contents of arterial and of external jugular blood showed a slightly decreased arteriovenous difference. These authors concluded that the cerebral oxygen consumption was decreased as a result of the trauma, and suggested that the ability of the nerve cells to use oxygen may be directly impaired by injury.

The present report on experimental craniocerebral trauma in dogs includes data on the oxygen saturation of the arterial blood and on the cerebral arteriovenous differences in oxygen, carbon dioxide, and glucose, the cerebral blood being taken from the sagittal sinus. Chemical studies of cerebral tissue have been made by the technique of freezing the brain *in situ* prior to removal of specimens for analysis. This procedure stops all metabolic processes in the tissue and prevents postmortem chemical changes.

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Since it has previously been shown that acute anoxia induces rapid lactic acid formation and phosphocreatine decomposition in cerebral tissue (21), it is to be expected that any serious disturbance in the cerebral oxidative metabolism following head injury would manifest itself in similar changes.

It is generally recognized that glucose supplied by the blood is the primary substrate of the cerebral oxidative metabolism. One of the chief mechanisms of glucose catabolism in the brain is the well known phosphorylation cycle of Meyerhof and others (2, 7, 14), in which glucose is converted to hexose phosphate and subsequently through a series of reactions is transformed to pyruvic acid. In the presence of adequate oxygen, pyruvic acid is further oxidized to carbon dioxide and water through a series of steps not yet elucidated; in absence of oxygen, pyruvic acid is converted to lactic acid.

Whether other pathways for oxidation or for lactic acid formation exist in cerebral tissue is disputed (2, 3, 7, 14), but the phosphorylating mechanism is undoubtedly present and functioning. The present study deals with some of the constituents involved in this cycle: lactic acid, the level of which (in cerebral tissue) appears to depend primarily upon metabolic conditions such as oxygen supply and functional activity or oxidative rate; adenosine triphosphate, which acts as a phosphate carrier in the phosphorylation of glucose and various intermediary metabolites; phosphocreatine, which functions as an organic phosphate reservoir in equilibrium with adenosine triphosphate; inorganic phosphate, and other acid-soluble phosphorus compounds the significance of which is still obscure. In some experiments the iron contents of the tissue specimens were determined to

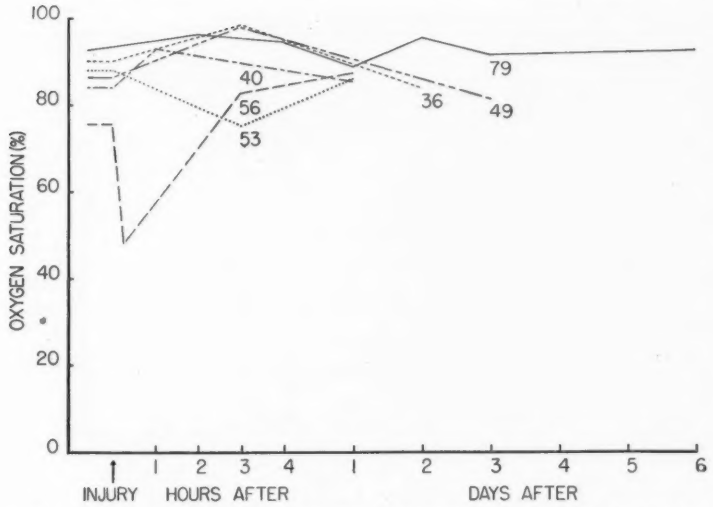

Fig. 1. Changes in the oxygen saturation of the arterial blood after head injury. Numerals identify individual experiments.

estimate the amounts of blood present, and determinations of the acid-insoluble phosphorus (phospholipid and nucleoprotein) were used as possible indication of presence or absence of localized edema.

PROCEDURES

Mongrel dogs weighing between 5 and 15 kilograms were used. Morphine analgesia was employed in doses of 20 milligrams per kilogram, and infiltration with ¼ of 1 per cent procaine was used for exposure of vessels and other operative procedures. Blood specimens were drawn over mercury from the femoral artery and the femoral and external jugular veins, without stasis, before and after injury. Specimens were obtained also from the sagittal sinus after injury. In 1 to 6 day preparations the skin incisions were opened each day and closed again after the wound was sprayed with sulfanilamide powder. These wounds remained remarkably free from infection.

The head injuries were administered with a 1 pound hammer or with a device previously described (5) in which the striking object is propelled by springs. In acute experiments the scalp and masseter muscles were reflected before injury. In 1 to 6 day preparations the head injury was made over the intact scalp.

The degree of injury (physiological response) and the cerebral contusions were classified as previously described (5). The state of consciousness was evaluated, as before, by observing the animal's response to tail pressure. In one instance (dog 56) the injury was classified as "profound" despite the fact that the animal survived until sacrificed 24 hours later; this animal was kept alive only by giving artificial respiration for 7 minutes after the blow. In 3 animals sacrificed 15 to 50 minutes after injury the classification "profound" was used since the injury was so severe that survival appeared to be extremely improbable. In one of these, artificial respiration was necessary for 5 minutes.

In acute experiments the blood pressure was recorded from the femoral artery and respiration from a balloon about the thorax or from an intratracheal tube. The skull was exposed through a median incision and the masseter muscles were reflected laterally. After the injury had been administered, a trephine opening was made over the sagittal sinus and blood specimens were obtained. The bone of the calvarium was cut away until the superior lateral aspects of both hemispheres were exposed. The dura was opened and reflected. The brain was frozen *in situ*

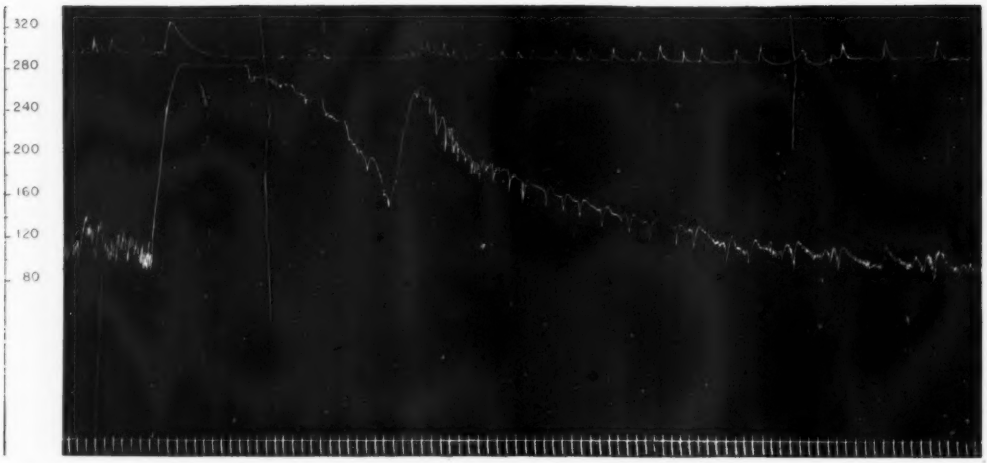

Fig. 2. Blood pressure and respiration in a profoundly injured animal. The third blow caused a marked pressor response, with loss of respirations for 50 seconds followed by occasional respiratory movements for 130 seconds. With return of respiration there was a return of blood pressure to the normal level. Lid reflexes returned 21 minutes after blow, but animal remained unconscious. The brain was frozen 36 minutes after injury. A contusion subjacent to the fracture showed typical chemical changes, while in an unbruised contralateral area no changes were found.

with liquid air (9) and specimens of tissue were removed for chemical analysis. Cortical areas from which specimens were obtained included the postcruciate, coronal, ectolateral, suprasylvian, and ectosylvian gyri.

In 1 to 6 day experiments the procedure was similar except that blood pressure and respiration usually were not recorded.

CHEMICAL METHODS

Oxygen content and capacity and carbon dioxide content of blood were determined by the Van Slyke-Neill manometric methods (15).

Blood glucose was determined on zinc hydroxide centrifugates by the method of Hagedorn and Jensen as modified by Kramer and Steiner.

Lactic acid was determined by the method of Barker and Summerson.

The methods for fractionation and determination of the acid-soluble phosphorus compounds have been described (20). Precipitation by means of calcium hydroxide and 10 per cent ethanol separates inorganic phosphorus, most of the nucleotide phosphorus, and an acid-stable fraction which seems to consist largely of hexose-6-monophosphate. Unprecipitated are phosphocreatine, an acid-stable fraction precipitated by 80 per cent ethanol, and an ethanol-soluble fraction.

The nucleotide phosphorus present in normal brain consists mainly of adenosine triphosphate, but may include a small amount of guanosine triphosphate (10). These compounds appear in the Ca-insoluble fraction. Two of the three phosphate groups in each case are freed by acid hydrolysis, while the third remains combined with the ribose component of the molecule. The ribose component is quantitatively determined by an adaptation of Bial's reaction for pentoses, and the amount of attached phosphorus calculated. In normal cerebral tissue, this equals half the acid-hydrolyzable phosphorus precipitated. Adenosine diphosphate, if present (as in postmortem tissue), appears in the precipitate, but adenylic acid (adenosine monophosphate) is found in the Ca-soluble fraction. Only a trace of such Ca-soluble pentose-containing material is found in normal cerebral tissue; an increase (such as is found postmortem) is indicative of decomposition of adenosine triphosphate.

Iron was determined in the washed trichloroacetic acid precipitate by the method of Kennedy (8), and the amount of blood in

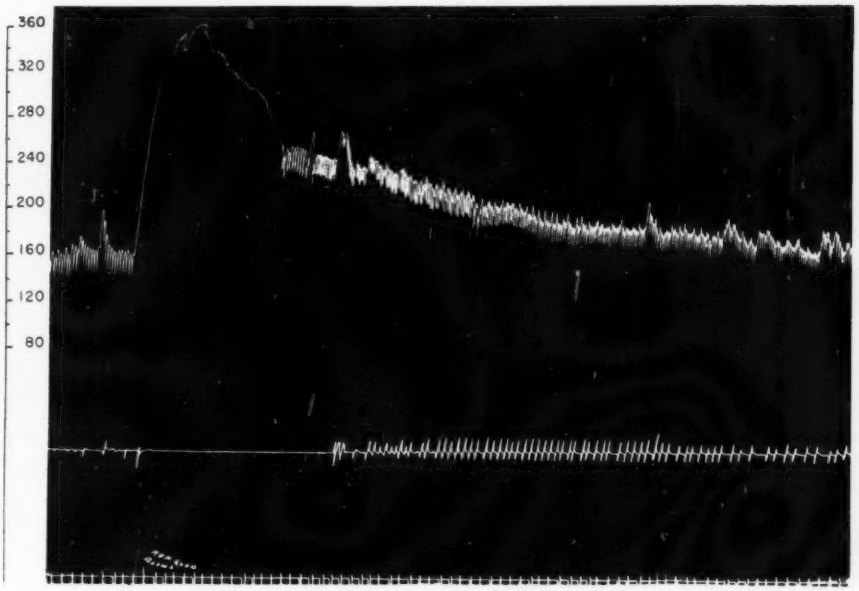

Fig. 3. Blood pressure and respiration in a moderately injured animal. The second blow caused a marked pressor response with loss of respirations for 102 seconds. No loss of lid reflexes occurred. The animal did not respond to pain from tail pressure but responded to pain from manipulation of the dura. The brain was frozen 37 minutes after injury. A contusion subjacent to the fracture showed typical chemical changes. An unbruised adjacent area showed slight changes, while a contralateral area gave normal values for the constituents determined.

the specimen calculated from the equivalent oxygen capacity (15) and the oxygen capacity of the animal's blood. Allowance was made for a trace of nonhemoglobin iron present: this, determined on the perfused brains of 2 animals, was 0.8 milligram per 100 grams.

Acid-insoluble phosphorus was determined on appropriate aliquots of the digests used for iron determinations.

RESULTS

Oxygenation of arterial blood. The most common finding was increased oxygenation after head injury. This was observed in 22 of a total of 30 animals in which samples were obtained 14 to 180 minutes after injury. One animal showed no change, and 6 showed mildly decreased oxygenation. One profoundly injured animal with respiratory paralysis (dog 56) was given artificial respiration manually for 7 minutes, after which the respiratory function recovered. Arterial blood drawn 15 minutes after injury showed an oxygen saturation of only 49 per cent: 150 minutes later the oxygenation had recovered to a value of 81.3 per cent, which was slightly higher than the initial level. The results of several experiments are plotted in Figure 1. The variations in the arterial blood gases are to be ascribed to respiratory changes, for the most part. Figures 2 and 3 show typical changes in respiration and blood pressure.

It may be noted that morphine induces only minor changes in the arterial blood gases. Average values showed a slight decrease in oxygenation and a corresponding increase in carbon dioxide content, indicating a very mild depression of respiratory activity, as compared with control animals given only local anesthesia.

Cerebral arteriovenous differences. In the injured animals no significant changes occurred in the cerebral arteriovenous differences in oxygen, carbon dioxide, and glucose. Deter-

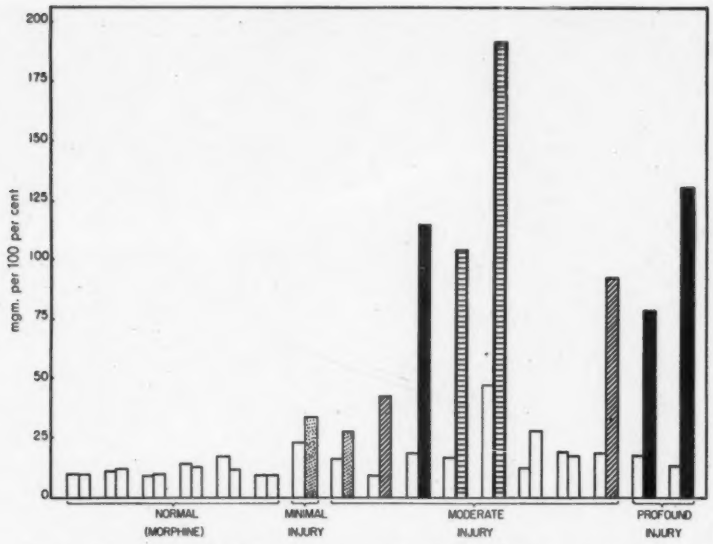

Fig. 4. Effects of cranial trauma on cerebral lactic acid, 20 to 85 minutes after injury. In areas of contusion there are great increases in lactic acid, roughly correlated with the grade of contusion but not with the degree of physiological injury. In areas which show no visible evidence of contusion there is sometimes a higher than normal lactic acid level; in other instances the level is normal, even in profoundly injured animals. Each pair of columns represents one brain. Right column shows result in specimen from area subjacent to fracture; left column from area contralateral to fracture. White column, no contusion; dotted columns, contusion grade 1; diagonal lines, contusion grade 2; horizontal lines, contusion grade 3; black, contusion grade 4.

minations made 18 to 75 minutes after injury in 12 animals gave an average of 8.6 volumes per cent oxygen removed from the blood as it passed through the brain. The corresponding average value in 21 morphinized control animals was 7.6 volumes per cent. The average values for carbon dioxide added to the blood were 7.6 volumes per cent in the injured animals and 7.9 volumes per cent in the controls. The average values for glucose removed from the blood were 14 milligrams per cent after injury (7 animals) and 12 milligrams per cent in the controls.

No generalized disturbance in the cerebral metabolism is revealed by these data. If any decrease in the oxidative rate occurred it was paralleled by a decrease in the cerebral blood flow. No measurements of the latter were attempted in these experiments. It should be noted that any increase in intracranial pressure was relieved by the trephine opening before the blood specimens were drawn.

In 4 control animals the cerebral arteriovenous differences were determined both with and without morphine analgesia. The average differences found without morphine were 6.3 volumes per cent of oxygen and 6.2 volumes per cent of carbon dioxide. Under morphine the average differences for the same dogs were 4.8 volumes per cent of oxygen and 6.0 volumes per cent of carbon dioxide. Decreases occurred in 3 instances and increases in 1.

Blood from the external jugular vein showed a higher oxygen saturation than that from the sagittal sinus in normal and injured animals. It is evident from the data that in the dog the blood of the external jugular vein is a mixture of cerebral venous blood with variable amounts of blood from other parts of the head, and is not suitable for studies of cerebral metabolism.

Chemical changes in cerebral tissue. Acute changes have been studied in 15 injured animals, 15 to 85 minutes after injury. Areas of

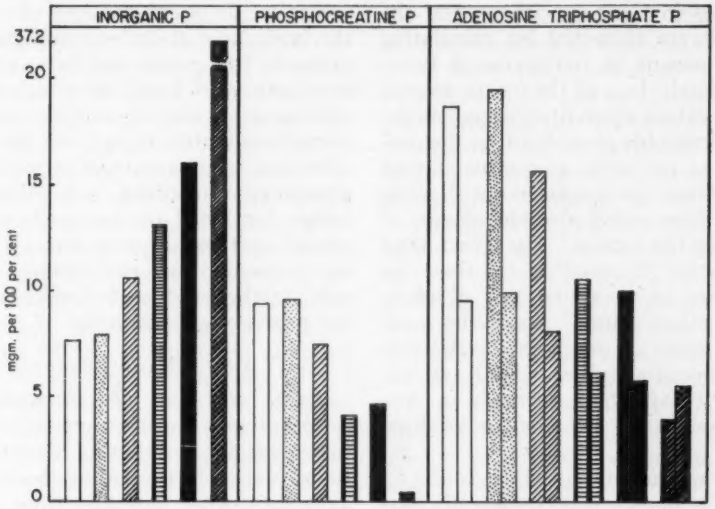

Fig. 5. Effects of cranial trauma on cerebral inorganic phosphate, phosphocreatine, and adenosine triphosphate, 20 to 85 minutes after injury. Unshaded columns represent averages of values from 6 uninjured dogs. Shaded columns represent averages of values from 2 to 4 animals. No changes are found after injury in unbruised areas or in grade 1 contusions. With more severe bruising, inorganic phosphate is increased at the expense of the organic fractions. Still greater changes occur postmortem in animals not subjected to cranial trauma. In the case of adenosine triphosphate, 2 of the 3 phosphate groups are determined after acid hydrolysis. The third, which remains bound to the ribose component, is calculated from a determination of the ribose. The normal 2 to 1 relationship changes but little in contusions. After postmortem decomposition for 30 minutes, the lower ratio indicates that the nucleotide remaining in this fraction is mostly the diphosphate. White columns, no contusion; dotted columns, contusion grade 1; diagonal lines, contusion grade 2; horizontal lines, contusion grade 3; black columns, contusion grade 4; black with white diagonal lines, postmortem. In the adenosine triphosphate group the right column shows acid hydrolyzable P, the left column ribose monophosphate P.

the cortex showing no macroscopic evidences of contusion often appeared to be entirely normal as regards the chemical constituents studied, even in profoundly injured animals. In other cases the lactic acid was slightly or moderately increased in areas showing no petechial hemorrhages. Changes in acid-soluble phosphates were absent from these areas or were so small as to be of doubtful significance. In one animal the specimen contralateral to the injury showed normal phosphates and only a slight increase in lactic acid, although on the injured side there was extensive laceration with extrusion of much cerebral tissue, and the animal remained unconscious to the end of the experiment.

Areas of the cortex which had sustained visible contusion showed marked chemical changes which were roughly proportional to the degree of local damage but bore no relation to the physiological response of the animal. Lactic acid changes in representative experiments are shown in Figure 4, and changes in acid-soluble phosphates in Figure 5.

A question immediately arose concerning the effects of extravasated blood on the chemical findings in areas of contusion, especially as to the apparent decreases in acid-soluble phosphorus compounds. The possibility of a localized edema also required consideration.

In 6 experiments the amounts of blood in the tissue specimens were estimated from iron determinations. It was found that grade 4 contusions might contain as much as 30 per cent blood, while normal tissue contained about 5 per cent. Acid-insoluble phosphorus

was determined in these specimens, and the values found were corrected by calculating the amounts present in 100 grams of tissue exclusive of blood. In 5 of the 6 experiments the corrected values showed an apparent decrease of acid-insoluble phosphorus in the contusions (6 to 14 per cent) as compared with contralateral areas; the specimen not showing this decrease represented a milder degree of contusion than the others. The effect may have been due to "dilution" of the tissue by localized edema or to actual loss of phosphorus from other causes. Since the acid-insoluble phosphorus represents relatively stable tissue material (phospholipid and nucleoprotein), its apparent decrease in contusions is thought to be due to localized edema.

In these 6 experiments the values found for the acid-soluble phosphorus compounds were corrected by calculating the amount of each constituent present in 100 grams of tissue exclusive of blood, and exclusive of apparent edema fluid in the contusions. Allowance was made for the acid-soluble phosphorus compounds in the blood. However, after the corrections were applied the results remained qualitatively the same as shown in Figure 5.

It is therefore concluded that in areas of contusion there occur formation of lactic acid and partial decomposition of phosphocreatine and of adenosine triphosphate, with accumulation of inorganic phosphate. The nucleotide phosphorus which remains is chiefly adenosine triphosphate, with little or no adenosine diphosphate. The ribose component of the decomposed adenosine triphosphate apparently disappears. A slight loss of total acid-soluble phosphorus usually occurs. The corrected values for "residual organic phosphorus" fractions did not indicate the occurrence of significant changes.

Later course of changes. In 11 experiments, cerebral tissue was obtained for analysis 1 to 6 days after injury. The findings are similar to those immediately after injury. Precise evaluation is impossible in the absence of a method for producing strictly comparable injuries in different animals, but there appears to have been a measure of recovery as regards lactic acid and phosphocreatine in several of these experiments. In no case was the lactic acid above 100 milligrams per 100 grams in this group, and in several instances low lactic acid levels were found in grade 1 contusions, in striking contrast to the findings immediately after injury. In one experiment there was an apparent loss in "residual organic phosphorus" fractions, but unfortunately no values for blood in the specimens were obtained in these experiments. These results are presented as preliminary experiments only; further studies of chemical changes during recovery are planned.

ANALYSIS OF OBSERVATIONS

Lactic acid and phosphocreatine levels in cerebral tissue. In the course of this and other investigations a series of determinations of blood plasma lactic acid has been made simultaneously with determinations on cerebral tissue frozen *in situ* under various conditions. The data confirm previously published evidence (18) that the cerebral lactic acid is independent of the level in the blood, being in some instances much higher and in others much lower. Other workers have shown that the "hematoencephalic barrier" is relatively impermeable to anions (4). Since lactic acid is largely ionized at the pH of the blood, it is probable that its rate of diffusion between blood and brain is relatively low. From observations of the effects of hypoxia and other conditions on the cerebral lactic acid level it is evident that the latter is regulated primarily by metabolic conditions within the cells. Experiments have shown that in dogs under morphine the cerebral lactic acid begins to increase when the oxygen in the respired air is reduced to between 11 and 13 per cent (oxygen-nitrogen mixtures), at which level the oxygen saturation of the arterial blood is 55 to 65 per cent. Varying the period of hypoxia between 15 and 60 minutes does not change the lactic acid level. Upon readmission of air after relatively mild degrees of hypoxia the cerebral lactic acid level returns to normal within 10 minutes; for the more severe degrees of hypoxia within 45 minutes.

The phosphocreatine level in the brain is decreased by hypoxia, the decomposition beginning at oxygen levels of approximately

7 per cent in the respired air, corresponding to an arterial blood oxygen saturation of 23 to 35 per cent. Complete recovery of phosphocreatine occurs within 10 minutes after readmission of air in even the most severe degrees of hypoxia studied.

The lactic acid and phosphocreatine in the brain may also vary with the oxidative rate or with the functional activity of the neurones. Lactic acid values found in mice under ether or barbiturates are lower than those in unanesthetized controls. Phosphocreatine is increased by barbiturate anesthesia. Lactic acid is increased by sensorimotor activity (exercise) and in convulsions induced by picrotoxin or metrazol (18, 19). In dogs, morphine analgesia gives more uniform lactic acid values with a slightly lower average than does barbiturate anesthesia (11).

Unbruised areas from injured brains. The cerebral lactic acid and phosphocreatine levels found after craniocerebral trauma do not indicate the occurrence of a generalized cerebral anoxia. Since mild degrees of hypoxia, well tolerated by the animal, are sufficient to cause increased lactic acid in the brain, the frequent finding of normal lactic acid levels in apparently undamaged areas of the cortex in animals suffering from profound injury may be taken as an indication that the oxygen supply and utilization is sufficient in these areas.

In other instances, in the presence of adequate arterial oxygen, the occurrence of higher than normal lactic acid levels in areas which show no visible evidence of contusion may represent a mild degree of local damage. This interpretation is suggested by an experiment in which such an area was found directly beneath the skull fracture, together with a lower (normal) lactic acid level in contralateral area. However, the *occasional* occurrence of a generalized disturbance in cerebral oxidations is not excluded by these experiments.

In some instances subdural hemorrhage occurred. The cerebral tissue subjacent to such mass lesions was often found to be normal with regard to lactic acid and phosphorus compounds. It cannot be denied that with the skull intact a subdural hematoma may cause localized anoxia by compression which would not be present when the bone is removed and the brain is decompressed. The same is true of severe degrees of brain swelling.

Contusions. The chemical changes in areas of contusion are comparable to those in cerebral anoxia in that lactic acid is formed and phosphocreatine decomposed, with accumulation of inorganic phosphate. The two conditions differ markedly in respect to adenosine triphosphate, which is decreased by contusion but not by the most severe oxygen deprivation studied, a level of 4.2 per cent in the respired air, which approaches the level of fatal anoxia. The disappearance of small amounts of acid-soluble phosphorus from areas of contusion is not paralleled in hypoxia.

Chemical changes occurring in cerebral tissue postmortem include decomposition of phosphocreatine and adenosine triphosphate. The decomposition products of the latter are found as adenosine diphosphate, adenylic acid, a nucleoside or free pentose, and inorganic phosphate (20). In areas of contusion the findings differ in that phosphocreatine and adenosine triphosphate do not completely decompose; furthermore, the organic products of the decomposed adenosine triphosphate have largely disappeared.

The chemical changes in areas of contusion may be the result of a combination of direct injury to the cells and anoxia resulting from local vascular damage.

Animal-human correlations. The reaction of the human patient to head injury differs in some respects from that of the dog. In the latter, either the injury causes death within a period of a few minutes to an hour, or the effect is comparatively mild, the animal recovering to a relatively normal state within an hour or two after the blow. Lengthy periods of unconsciousness lasting for many hours or days, such as are frequently seen in the human, have not been observed in the dog in the course of these experiments.

There is also a marked difference between the animal and the human in the pattern of delayed death. In the animal, delayed death is associated with failing circulation of a shock-like state and gradual respiratory failure. The clinical findings of increasing blood pressure with bradycardia followed by pulmonary edema commonly noted in the

human were not observed in the experimental animal. In the human, anoxic anoxia may be a factor in the presence of pulmonary edema.

There was a marked difference in the incidence of subdural and epidural clots. Although these lesions are common in the human, they were rare in the dog. Anatomical differences between the human and the dog probably account for these variations. There are fewer pial-dural venous connections in the dog's brain, a circumstance which reduces the likelihood of rupture and subdural collections.

Contusions of the brain are common in the human with head injury. They have been observed in 47 per cent of 151 postmortem examinations, and in the 72 individuals there were 191 distinct bruises (6). The effects of areas of contusion on the general brain economy should be remembered in management of such cases. Further experimental work should clarify the value of oxygen therapy and its effects on the anoxic state in areas of contusion.

SUMMARY

1. The cerebral metabolism has been investigated in dogs subjected to experimental craniocerebral trauma.

2. The oxygen saturation of the arterial blood was usually found to be increased after head injury; in a few instances saturation was observed. These changes were due mainly to variations in respiratory function.

3. The cerebral arteriovenous differences in oxygen, carbon dioxide and glucose have been measured, cerebral blood being obtained from the sagittal sinus. Head injury did not cause significant changes in these values.

4. Specimens of cerebral tissue for chemical analysis were obtained by freezing the brain *in situ*. Studies were made of lactic acid and acid-soluble phosphorus compounds. In some experiments amount of blood in each specimen was estimated from iron content; acid-insoluble phosphorus also determined.

5. Areas of the cortex showing no macroscopic evidences of damage were sometimes entirely normal as regards the chemical constituents studied, even in profoundly injured animals. Since a mild degree of hypoxia causes increased lactic acid, it is concluded that no generalized disturbance in cerebral oxidations resulted from the head injury.

6. In other instances the lactic acid was slightly increased in cortical areas showing no macroscopic evidences of contusion, and in the presence of adequate arterial oxygen. This finding may represent either a mild degree of local damage or a more widespread disturbance in cerebral oxidative mechanisms in these animals.

7. Areas of contusion showed greatly increased lactic acid and inorganic phosphate and decreased phosphocreatine and adenosine triphosphate. The organic decomposition products of adenosine triphosphate had largely disappeared, in contrast to the findings in postmortem tissue. A slight loss of acid-soluble phosphorus usually occurred. These findings may be due to a combination of direct injury to the cells and anoxia resulting from vascular damage.

8. In brains studied 1 to 6 days after injury there appeared to be partial recovery as regards the lactic acid and phosphocreatine in areas of contusion.

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TRANSLOCATION OF THE PERONEUS LONGUS TENDON FOR PARALYTIC CALCANEUS DEFORMITY OF THE FOOT

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A DECADE ago von Baeyer (1, 2) wrote a rather broad article discussing the merits and procedures for translocation of tendons. The idea at that time was not new but was seldom used and he considered the procedure worthy of more common use and consideration. By translocation he meant the changing of the course of a tendon muscle preparation to perform a new function without severing the origin or insertion of the muscle. When such an operation was possible he believed that it had several advantages over the transplantation of tendons as is commonly done. It is not necessary to depend on the sutures to hold the tendon at its new point of insertion. Early function of the translocated muscle and tendon is possible, and fewer adhesions are likely to form. Von Baeyer also expressed the belief that the tension under which the translocated tendon and muscle were placed caused the muscle to hypertrophy and so better serve its function in taking over the duties in replacing a usually stronger muscle. He proved this latter point to his satisfaction in experimental animals and refuted previous beliefs that muscles under tension tend to atrophy. It is reasonable to assume that the stimulus to the reflex arc from one of these muscles is less disturbed when the origin, insertion, and physiologic tension of the muscle are kept intact.

No subsequent reports of this procedure as applied to the peroneal muscles have been encountered in the English literature by us. In searching for an operation which would supply active plantar flexion to a foot with a paralysis of the gastrocnemius and soleus muscles which had assumed a calcaneal deformity, the surgeons at the Gillette State Hospital for Crippled Children at St. Paul, Minnesota, believed the procedure as suggested by von Baeyer was worthy of a trial. The results from transplanting the cut peroneal tendons into the tendo achillis or the calcaneus had not been considered too successful. In 1937 a small series of these operations was begun and enough time has elapsed that an evaluation of this procedure should be made.

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A total of 13 patients have undergone this operation, the last one included in this group having been done in January, 1942. The patients selected all had had poliomyelitis and had reached the residual stage. One patient was operated on only 1 year after the acute episode of poliomyelitis; the remainder had had the disease at least 3 years prior to operation. The longest interval between the disease and operation was 8 years while the average was 5.1 years. The average age of these patients was 9.9 years, the youngest being 5 years of age and the oldest 15 years. There were 7 male and 6 female patients in the group.

The previous medical treatment had been of the conventional conservative nature with active physical therapy following the acute stage. Two patients had had previous surgical procedures: one patient had had a Hoke type of tendon transplant of the foot combined with plantar fasciotomy; in another case an unsuccessful attempt had been made to perform anterior bone block of the ankle.

The presenting complaint of all 13 patients selected for this operation was a calcaneus deformity. Seven of these had an associated valgus deformity of the ankle and foot. In 4 cases some cavus deformity was present. Careful evaluation of the muscle strength in all muscles of the leg was made (Table I). In the majority of cases the operation was done only when the strength in the peroneal muscle was rated as fair or better. In 2 cases in which the preoperative rating for the peroneal muscles was "poor," operation was performed. In 1 of these cases the result was poor while in

TABLE I.—PREOPERATIVE MUSCLE POWER AND RESULT OF OPERATION IN 13 CASES OF TRANSLOCATION OF THE PERONEUS LONGUS TENDON

Case	Preoperative muscle power						Result of operation
	Gastrocnemius	Flexor digitorum longus	Flexor hallucis longus	Tibialis posterior	Peroneus	Tibialis anterior	
1	Poor	Normal	Normal	Poor	Normal	Poor	Good
2	Poor	Fair	Fair	Fair	Good	Good	Good
3	Poor	Fair	Poor	Gone	Good	Gone	Poor
4	Trace	Fair	Gone	Fair	Normal	Good	Fair
5	Poor	Fair	Fair	Poor	Fair	Good	Poor
6	Trace	Gone	Trace	Gone	Poor	Trace	Very good
7	Trace	Gone	Gone	Poor	Fair	Fair	Good
8	Trace	Good	Good	Fair	Good	Good	Fair
9	Fair	Good	Good	Good	Good	Good	Excellent
10	Poor	Poor	Poor	Fair	Good	Good	Very good
11	Fair	Normal	Fair	Good	Normal	Good	Very good
12	Trace	Poor	Poor	Trace	Poor	Trace	Poor
13	Trace	Gone	Gone	Gone	Good	Gone	Good

the other it must be rated as very good. In all but 2 cases the power in the gastrocnemius and soleus muscles was rated from poor to trace. In two cases there was fair power in the gastrocnemius group and when this was supplemented by a sound peroneal which was translocated the plantar function of the foot was respectively excellent and very good.

Since the translocated peroneal tendon can at best only partially fulfill the function of the gastrocnemius and soleus muscles, any added strength from these muscles enhances the success of this operation. Likewise the strength of the flexor hallucis longus and the flexor digitorum longus as well as the posterior tibial muscle aids in plantar flexion; the latter muscle together with the peroneus brevis gives lateral stability to the foot. The power in the tibialis anterior muscle appeared not to have any effect upon the results from the procedure under discussion.

In only one of the cases in which operation was performed has it been found necessary to stabilize the foot by either a triple or a subastragalar arthrodesis. Two of the more severely involved patients are still wearing braces and may need some bony stabilization at a future date. One of these patients had a good result; the other obtained an unsatisfactory result.

OPERATIVE PROCEDURES

After the customary sterile preparation and draping, a tourniquet is applied to the thigh. A curved incision is made over the course of the peroneal tendons extending from about 2 inches (5 cm.) above the lateral malleolus, around this structure and to the point where the peroneus longus passes beneath the tarsal bones to its insertion on the lateral aspect of the base of the first metatarsal and the inferolateral aspect of the first cuneiform bones. The peroneal retinaculum is split and the peroneus longus tendon is mobilized. A second longitudinal incision is made around the apex of the heel in the midline and extending down to the periosteum. This incision is then connected with the first by deep subcutaneous dissection (Fig. 1). With a wide osteotome a V shaped groove is cut into the calcaneus over its apex for about 1 inch (2.5 cm.). This groove must be deep enough to receive the peroneal tendon (Fig. 2). With an ordinary button hook inserted in the second incision the peroneus longus tendon is pulled around into this new sulcus. Extreme plantar flexion of the ankle and foot aids in this maneuver. The tendon is inspected through the first incision and it is made certain that the plantar dissection has extended far enough medially to allow the tendon as direct a pull as possible in its new bed across the apex of the heel (Fig. 3).

The superior and inferior peroneal retinacula may then be repaired with a continuous suture or a few interrupted sutures of chromic catgut. Subcutaneous tissue is closed with interrupted plain catgut and the skin with plain interrupted zytor sutures. A padded cast is applied from the toes to the knee with the ankle in about 45 degrees of plantar flexion.

The foregoing procedure was used in the majority of cases; however, with several surgeons operating on this group there were some minor variations. Three incisions were used in 6 cases. In these cases the long curved first incision was not continuous and the peroneal tendon was removed from its bed

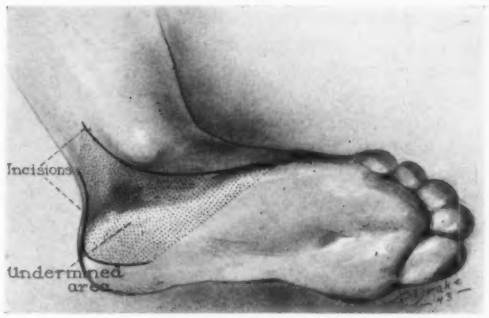

Fig. 1. Skin incisions and stippling indicating area of tissue undermined.

by subcutaneous dissection. In one instance the peroneus brevis tendon was cut and sutured into the tendon of the peroneus longus to give added muscle power. In another case the tibialis anterior as well as the peroneus brevis was transplanted, the former being sutured into the tendo achillis, the latter into the peroneus longus. In 3 cases long leg casts were applied and in 1 instance no cast at all was used.

Immobilization in plaster was maintained for about 3 weeks, at the end of which time the cast was removed, the wound was inspected and the stitches were removed. Active exercise was then begun in physical therapy. At the end of 5 to 6 weeks the patients were allowed to be up and walking with a heel elevated to correspond to the amount of plantar flexion which remained. This heel was gradually lowered over a period of several months until it was the usual or needed height. Physical therapy and muscle re-education were continued until the patients left the hospital, usually about 2 months after operation.

POSTOPERATIVE COMPLICATIONS

In only 3 of the 13 cases in which operation was performed did primary healing of the incision occur. There is a persistent tendency for the edges of the central portion of the undermined area to slough. In all cases the incision eventually healed. The average healing period was 2 to 3 months; the longest healing period was 6 months. In 1 case pinch grafts were used to hasten healing. In the later cases great care was taken to separate

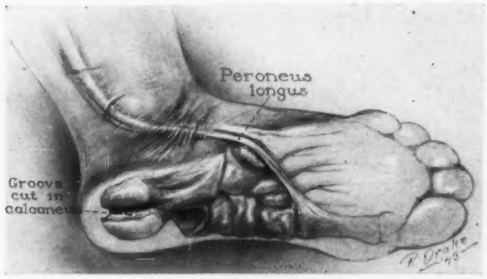

Fig. 2. Groove in calcaneus for reception of peroneus longus tendon.

the incisions as far as possible and to carry out the subcutaneous tunneling as close to the bone as possible. The circulation in the intervening tissue then appeared to be more adequate than when the earlier procedure was used and better healing was obtained.

RESULTS

While strength and function in transplanted or translocated tendons and muscles are sometimes difficult to estimate, in the cases here considered it is possible to make some very definite conclusions. The results were classified in 5 groups. When the deformity persists the result obviously is *poor*. With the deformity corrected but muscle power poor, only a *fair* result can be recorded. When walking power is present with some "push-off" the result is considered *good*. If the patient is able to stand on the toes of both feet the result is considered to be *very good* and when he is able to stand alone upon the toes of the foot on which operation has been performed an *excellent* result has been attained.

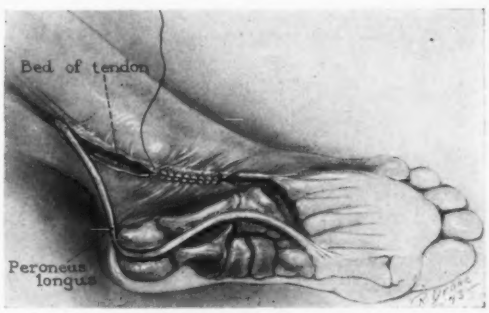

Fig. 3. Tendon mobilized from its bed and transferred to prepared groove. Closure of peroneal retinaculum.

Fig. 4. Patient sustaining entire weight on foot on which operation was performed.

The greatest improvement in the strength of the transposed muscle takes place from about the 3d to the 6th month after operation.

In this small series there were 3 poor results, 2 fair results, 4 good results, 3 very good results, and 1 excellent result (Fig. 4). In summarizing the results of operation, there were 8 satisfactory end-results and 5 cases in which there was little if any improvement.

The peroneal tendon was re-explored in 3 instances. In 2 cases it was loose and in the 3d it was frayed out. In all cases the tendon was tightened and in 2 the strength of the peroneus brevis was added by transplanting it onto the calcaneus. The results remained poor and subsequently an anterior bone block operation was performed on one patient.

Two of the poor results can be definitely attributed to the transposition of a peroneus longus tendon which was too weak to be of value in its new function. One tendon became frayed out from what was probably an improperly prepared bed. No definite cause could be determined in the other 2 unsatisfactory results.

CONCLUSIONS

Transposition of the peroneus longus tendon in calcaneal deformities of the foot has produced satisfactory results in a sufficient number of cases to warrant a continuation of its use. The best results have been obtained when the operation was done on patients who had slight remaining power in the gastrocnemius muscle and fair or better power in the transposed peroneal muscle. It is our opinion that the results in this procedure are strikingly better than if the peroneal tendon is cut and transplanted into the tendo achillis or calcaneus.

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FRACTURES OF THE NECK OF THE FEMUR

An Analysis of 157 Intracapsular and Extracapsular Fractures

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THIS study analyzes the management of 157 consecutive fractures of the neck and intertrochanteric region of the femur seen on the Fracture Service of the Third (New York University) Division of Bellevue Hospital from January 1, 1941, to June 30, 1943. It is our contention that immediate internal fixation enhances the ability of feeble, undernourished patients to survive, permits their ambulation in bed, reduces the incidence of potential complications, and allows early ambulation with crutches.

INTRACAPSULAR FRACTURES

There is sufficient evidence that the older methods of treatment were unsatisfactory. The plaster spica, Russell's traction, well leg traction, and other conservative procedures "chained elderly people to the mattress" and subjected them to potential complications which endangered their lives with no assurance that union would follow (Fig. 1, a, b, c, d, e).

Changes in position for feeding, for use of the bed pan, or adjusting bed linen, accentuate the pain of an inadequately immobilized fracture and make sedation inevitable. Spontaneous motion in bed is restricted. Despite good nursing care, usually inadequate in charity hospitals, incontinence, cystitis, decubitus ulcers, sepsis, thrombophlebitis and hypostatic pneumonia beset the bedridden patient, and all militate against his surviving with a fracture which may ultimately heal.

The voluminous literature concerning the results of internal fixation for fractures of the hip attests to the general acceptance of this method of treatment as the procedure of choice. The question of subjecting the feeble patient to the tremendous risk of the operation has caused many surgeons to wait until the condition of the patient improves. In our experience many of these patients have continued to fail, and we have operated upon them when pain and impending complications from confinement to bed dominated the clinical picture. Most of our patients who died were over 70 years of age, undernourished, and poor risks, and were in the group initially treated by traction.

It has been our impression that those patients who were treated with internal pin fixation immediately or very shortly after admission had a better chance of surviving and had a smoother course than those in whom operation was delayed to wait for the condition of the patient to improve. While the operating room is being prepared efforts are made to combat shock and dehydration.

Attention must be centered primarily on saving the patient's life, and it is our thesis that by immediate internal fixation of all fractures about the hip the mortality from these injuries has been reduced and the incidence of union has greatly increased.

It may be argued that frail and feeble patients might not stand the operative procedure. Granting that such a possibility may arise, the fact remains that they may have difficulty surviving the complications of the conservative methods of treatment. While we admit that our mortality has been high, we do not attribute this to the method of treatment but rather to the pre-existing complications and delayed surgery as most of the deaths occurred in the group which had preliminary treatment with traction. Contributing factors have been the desire to obtain perfect reduction and proper placement of the transfixion nail; this occasionally required further manipulation, replacement of incorrectly placed guide wires and waiting for the development of the roentgenograms, all of which was time consuming.

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To lessen the shock and the ordeal of the operation in the feeble patient in whom on admission there is about 75 per cent alinement of the fragments or in whom the attempt to realine the fragments has resulted in only a 75 per cent reduction, we recommend transfixion without further manipulation. The delay due to further manipulation and to the necessity of reinserting guide wires and awaiting development of the roentgenograms is all cumulative. Such delay adds to the shock and ordeal of the operation and may have a telling effect on the patient's life. While the roentgenograms will not reveal the soundest observance of the principles of mechanical fixation, nevertheless a sound therapeutic procedure has been carried out if the transfixion and fixation is sufficiently firm to permit the patient to be out of bed in a few days.

We do not wish to offer any compromise in reduction or proper placement of the transfixion nail in the younger age group or well preserved individuals. We are well aware of the inherent dangers of taking this position. But in the feeble, frail individuals or those afflicted with serious medical problems, careful evaluation should be made of the ability of the patient to withstand any protracted surgical procedure. Under these circumstances some compromise in reduction is permissible.

It is logical that immediate transfixion helps to preserve the meager blood supply from the ligamentum teres and the torn capsular vessels. When thus adequately immobilized, there should be no rotation or shearing of the fracture surfaces or extension of damage to the visceral capsule which would jeopardize the effort to re-establish an arterial anastomosis and cement the fracture surfaces. The more proximal the fracture line the more urgent the need of immediate transfixion and the more desirable the need of the closest approximation of the fragments to normal.

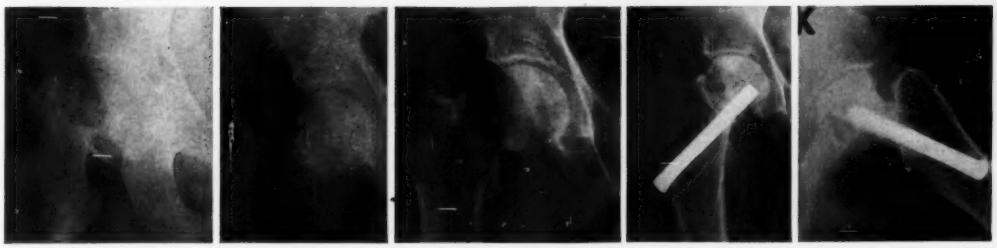
A majority of surgeons use the Smith-Petersen three flanged nail. Others favor various modifications of skeletal fixation, such as Henderson's lag screw, Moore pins, and the like. Our experience has been limited chiefly to the use of the cannulated three flanged nail. Those who use the three flanged nail feel that it meets the criteria of rigid fixation expressed by Watson-Jones, i.e., that (1) the flanges prevent rotary movement, (2) the length prevents angulatory movement, (3) there is a minimum of bone displacement, and (4) there is a maximum of surface contact.

The immediate and final results of internal fixation are therefore contingent, first, on the ability of the patient to surmount the ordeal of the operative procedure and become ambulatory; second, the ability of the disrupted blood supply to re-establish its continuity and cement the fractured surfaces; and, third, the maintenance of the fragments rigidly in position until there is roentgenographic evidence of union—a factor depending on the second contingent.

Operative procedure of internal fixation. In patients of younger age and those well preserved, a general or spinal anesthesia is used. In the aged and feeble 30 cubic centimeters of 1 per cent procaine hydrochloride is introduced anteriorly into the joint and 30 cubic centimeters along the line of incision. Premedication with morphine should be used with caution in old people. Small doses of 1/6 grain may bring the patient to the operating room in marked respiratory depression. The decision as to immediate preoperative sedation is left to the anesthetist in the operating room.

In most instances reduction has been accomplished by the Leadbetter maneuver which is indicated in most cases by the heel palm test. The fractured extremity is then securely fixed on the traction table in a position of 20 to 30 degrees' internal rotation to maintain the neck on a horizontal plane and abducted with barely enough traction to maintain the limb in position. The other leg is maintained in a comparable position of abduction and slightly lower to allow sufficient room for placing the x-ray tube for taking the lateral roentgenograms.

After reduction is obtained an effort is made to establish bony landmarks to aid in the accurate insertion of the guide wire and pin. We eliminate complicated gadgets for directing the insertion of the nail. We follow the simple expedient of placing a Michel clip over the middle of the inguinal ligament as suggested by Moore. Another skin clip is added 1 inch below and ½ inch lateral to the femoral



a b c d e

Fig. 1. a, T.K., 54 years of age, had an intracapsular fracture on January 17, 1941. b, Satisfactory restoration of fragments in bilateral Russell traction with abduction. c, Absorption of the neck from shearing and rotation resulting from the constant though limited motion in bed. d and e, Treated with internal fixation 3 months after admission to hospital. This patient regained complete function; followed 3 years.

artery. Both clips form opaque targets and are utilized as focal "sights" for gauging the direction of the guide pins.

The distortion of the skin clips on the roentgenograms should be avoided so as to obtain the fullest advantage of these focal points in expediting the operation. This distortion can be prevented (1) by keeping the patient's pelvis absolutely horizontal on the tunnelled cassette holder; (2) by centering the x-ray tube over the neck of the femur and parallel to the hip and pelvis; (3) by placing the skin clip in the obese on the overhanging skin at a site corresponding to the midpoint of the inguinal ligament.

The time of the operative procedure depends on the rapidity with which we can take and develop the plates. We do not use the fluoroscope for checking our reduction and have tried to make 3 sets of x-ray plates serve our purpose: the first to check reduction and locate the skin clips in relation to the head, the second to locate the position of the guide pins, and the third to check the position of the three flanged nail.

The use of two machines has simplified our procedure since once the machines are properly located the operative field can be draped without being disturbed by subsequent manipulations of the machine for check roentgenograms.

Operation. While the first set of roentgenograms are being developed, a burr hole, somewhat smaller in diameter than the Smith Petersen nail, is drilled 1 inch below the protruding ridge of the lower end of the great trochanter as suggested by Watson-Jones. We have found, that by beveling the lower outer and upper inner borders of the burr hole with a small osteotome, the guide wires are not deflected by the overhanging ridges of the cortex.

Having determined the relation of the skin clips to the head of the femur, two calibrated guide wires are inserted in the direction of the middle and inner quadrant of the head. In the insertion of the wire through the medulla of the neck, the operator should be able to push the wire in without drilling until the wire hits the head. If it fails to enter easily, it is striking the cortex along the wall of the neck and should be redirected.

In high subcapital fractures the guide wire is drilled for a short distance into the acetabulum as recommended by Henderson. This step anchors the head, prevents its rotation when the oncoming nail crosses the fracture site, and the nail is less apt to impinge on the guide wire.

As indicated by the second series of roentgenograms, the better of the two guide wires is used for the insertion of the nail. Preferably, the nail should traverse the fracture line in the most vertical position so that the superimposed body weight will be directed through, rather than across, the fracture line. To determine whether the wire is encroaching on the pin it is sufficient occasionally to rotate the wire without extracting it. The drapes remain on the patient until the final roentgenograms are approved.

It is our opinion that the three series of roentgenograms are essential to the success of

the operation. The elimination of any one series of roentgenograms may jeopardize the ultimate outcome.

The insertion of a nail without the aid of guide wires may save time; but if the nail is misdirected and requires reinsertion, no time is saved, and there is added risk of damage to the cancellous bone and its blood supply.

With the developing facilities near the operating room, and with the aid of a rapidly acting developer, the waiting time can be appreciably lessened.

Postoperative care and follow up. A light plaster boot to the knee with a horizontal board reinforced with plaster behind the heel is applied in the operating room. This insures against outward rotation of the leg and disimpaction of the nail. We do not permit patients to be turned on the uninjured side. We partially attribute to this procedure the disengagement of the nail from 5 high subcapital fractures and therefore caution against it. Quadriceps exercises are encouraged, and the patient is allowed out of bed in a week.

Weight bearing is deferred until union is roentgenographically evident. However, few of our patients use their crutches properly. It is significant that the patients with the greater angles begin bearing weight sooner, complain less, and dispense earlier with their crutches without any untoward effect.

ANALYSIS OF RESULTS OF THE TREATMENT OF INTRACAPSULAR FRACTURES

There were 57 intracapsular fractures. Fifty-three were treated by internal fixation; 47 with a Smith-Petersen nail, 5 with a Smith-Petersen nail and Hawley bar, and 1 by Moore pins for a spontaneous fracture following radiation for carcinoma of the cervix. One patient was treated by external fixation with Roger Anderson half pins. Three patients were treated by Russell traction.

The three hips treated by Russell traction were impacted abduction fractures. Only enough weight was applied to keep the leg from rotating outward. The position of the fragments did not change during the 3 months the patients remained under observation.

Twenty-eight of the 54 patients were operated upon as soon after admission as facilities could be arranged; 16 others, within 8 days, 7, within 21 days, and the remaining 3 were operated upon one on the 25th day, another at the end of 2 months and the third at the end of 4 months.

The patient who was treated by external fixation with half pins developed infection at the site of insertion of a distal pin. The patient was followed for 11 months. The fracture united and he is back at work (Figs. 2, a, b, c, d).

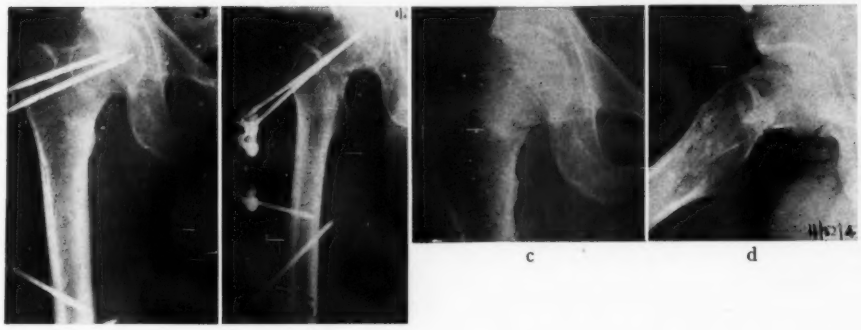
Mortality. Of the 52 cases treated with the Smith-Petersen nail, 5 died, (9.6 per cent). They were 68, 79, 84, 75, and 70 years of age. Their nutritional status on admission was poor. They were first treated in traction for 12, 3, 2, 37, and 8 days, respectively. They continued to do poorly and were operated upon under local anesthesia in the presence of some complication. They died on the 5th, 5th, 7th, 103rd, and 21st day, respectively, after their operation.

Extrusion of the nail from the proximal fragment. In 5 patients the nail slipped out of the proximal fragment. They were reinserted. This occurred on the 4th, 7th, 12th, 13th, and 42nd day. We attribute this to (1) promiscuously turning the patient on the uninjured side in bed and (2) failure of the nail to engage the proximal fragment adequately.

Follow-up. Forty nine, of the 54 patients (91 per cent) were followed; 15 for 1 to 3 years, 8 from 7 to 12 months, and 7 from 4 to 6 months. Nineteen were observed for less than 3 months. Some of those followed for short periods were sent to institutions from which it would be inexpedient to have them return.

One year after nailing a low transcervical fracture, a hiatus, ½ to ¾ inch developed. The nail straddled the fragments without any change in the position of the head and shaft. A fibular graft, which broke weeks later while the hip was immobilized in a double spica, did serve to establish vascular channels to the proximal fragment and by its osteogenesis has served to fill the hiatus.

There has been 2 cases of aseptic necrosis of the head. Both occurred in high subcapital fractures. In one the nail extruded from the head and was reinserted, while in the other there was a gradual shortening of the neck and



a b c d

Fig. 2. a, b, A.S., January 25, 1943, 57 years of age, intracapsular fracture transfixed with Roger Anderson half pins. Note penetration of the opposite cortex by the distal pin. c, d, Pins were removed 2 months after insertion. Patient has been followed for 10 months and has fully regained the function of his hip.

subsequent necrosis of the head in a woman who had a kidney removed for carcinoma.

While subjective complaints suggestive of traumatic arthritis have occasionally been encountered, they have not been substantiated by roentgenographic evidence.

While it is too early to evaluate our end-results, we believe that in many cases the procedure has been a life saving measure and that the results have been satisfactory.

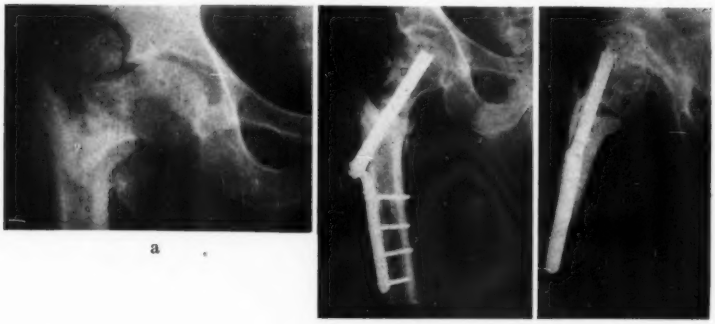
EXTRACAPSULAR (INTERTROCHANTERIC) FRACTURES

In our experience the intertrochanteric fracture has had a higher morbidity and mortality than the intracapsular fractures. In our series there are 100 patients, (64 per cent) with extracapsular injuries as compared with 57 (36 per cent) with intracapsular fractures. Our mortality for extracapsular injuries was 22 per cent compared with 8.7 per cent for the intracapsular fractures.

It is an erroneous impression that the intertrochanteric fracture is not as serious as the intracapsular injury. The patients are subjected to more shock and to the same potential complications as in the intracapsular injuries. There is frequently extensive comminution and more marked external rotation of the shaft because the shaft is not restricted by the capsular attachment which is proximal to the fracture line. There also is a greater extravasation of blood, more marked deformity and considerably more pain and restriction of motion. Even in lieu of these facts the profession has assumed that intertrochanteric fractures are not serious problems because union takes place frequently with or without treatment.

While the pertinent problems in the treatment of intertrochanteric fractures are the same as in intracapsular fractures, namely: (1) can we avoid the potential complications which follow hip fractures, (2) can a method of treatment be employed which offers the patient a reasonable chance to survive with a useful hip—the failure to correct the disturbed relation of the intertrochanteric fragments in the debilitated and aged is of secondary importance.

Bilateral Russell traction for intertrochanteric fractures. While it is generally acknowledged that the diminished angle of the neck and external rotation in intertrochanteric fractures can be corrected by unilateral or bilateral Russell traction, it does not provide rigid immobilization of the fracture site. However, the limited motion at the hip in traction does not prevent union. It is recognized that traction in moderate abduction must be uniform and sustained uninterruptedly by having (1) the foot of the bed elevated, (2) the back rest maintained in a lowered position, and (3) the spreader to which the leg traction is attached prevented, even momentarily, from resting against the foot of the bed. If attention to these details can be assured, and the surgeon



a b c

Fig. 3. a, G.P., 53 years of age, sustained an intertrochanteric fracture in September, 1942. Was in the hospital 3 times in 6 months; refused treatment and walked around with crutches. Pseudoarthrosis. b, c, Nine months after the insertion of a Smith Petersen nail and Hawley bar and immobilization in plaster. Union and function has been almost completely regained.

believes that the patient will stand the prolonged stay in bed without serious mishap, then this procedure is the simplest form of treatment that will insure the patient a good leg, with firm union, and in most cases a normal angle. This treatment requires between 6 to 8 weeks before sufficient union is present to permit the patient out of bed on crutches without weight bearing.

Assuming that the patient does survive any of the nonoperative methods of treatment, we cannot minimize the fact that he has had a prolonged and frequently a stormy stay in bed, and that not infrequently some disability results, i.e. a coxa vara deformity, shortening, external rotation and occasionally nonunion.

The *incidence of non union* is small because the extensive fracture surfaces are (1) usually impacted so as to limit rotary motion and (2) they are so adequately supplied with blood from the bone and the muscular attachments that union invariably results. Nevertheless non union may supervene if the mobility of the fragments is not restricted. Too early ambulation even with the aid of crutches will not restrict muscular contracture and upward displacement of the distal fragment. A coxa vara deformity, persistent outward rotation, or a pseudoarthrosis may result.

A striking incidence of nonunion of an intertrochanteric fracture with a well established pseudoarthrosis was observed in an unco-operative patient 53 years of age. Within 7 months he repeatedly interrupted his treatment in several institutions. It wasn't until the fragments were immobilized with a Smith-Petersen nail and a Hawley bar in a plaster spica that adequate fixation and union was obtained. A plaster cast was used for 6 months to insure immobility in this old injury. Nine months after the operation there is some roentgenographic evidence of union (Fig. 3, a, b, c).

Transfixion of intertrochanteric fractures. One can readily understand why surgeons have been reluctant to transfix intertrochanteric fractures by means of a three flanged nail. Such a nail driven through a comminuted fracture not infrequently causes a dispersion of the fragments. The grip of the nail in the shaft below the trochanter is much too short and inadequate. A Smith-Petersen nail or unsupported shaft pins of any type will not adequately immobilize this type of fracture. The superimposed body weight and contraction of the thigh muscles will also distort the insecurely fixed fragments so that any conceivable type of displacement may supervene. This explains the faulty mechanics involved in depending on this type of fixation alone. By fixing a Hawley bar to the Smith-Petersen nail and to the shaft of the femur a reasonably firm and adequate fixation could be assured. In 5 cases the screws holding the nail and bar became loose, resulting in a change in the positions of the fragments and necessitating fast-

ening or reinsertion of the screw. We used the Moore pins in 7 cases, and in none were we able to retain the position of the fragments. We have had no experience with the Thornton, Jewett, Casberg, or Thatcher devices. We have used Roger Anderson's external pin fixation as recommended by Anderson, McKibbin, and Burgess. Because of seepage and untoward results reported elsewhere in this paper we have discontinued using external pin fixation for fractures about the hip.

We believe that the blade plate devised by Moore and Blount (Fig. 4), will obviate the difficulties which we have had with the Smith-Petersen nail and Hawley bar. It is now our procedure of choice for fractures about the intertrochanteric region. By the use of this principle of fixation, the debilitated patient with an extracapsular fracture is offered the same advantages of treatment as the patient with an intracapsular fracture.

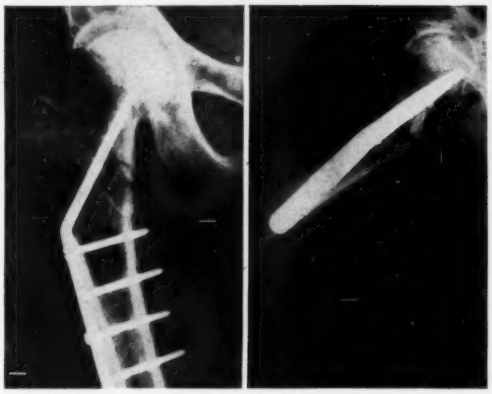


Fig. 4. a, left, and b, Mrs. E.Mc., 73 years of age, had a comminuted intertrochanteric fracture. Treated with a single angle Moore-Blount blade plate with no external fixation.

ANALYSIS OF THE RESULTS IN INTERTROCHANTERIC FRACTURES

There were 27 of the 100 patients who were treated by Russell traction alone, with 2 deaths (7.4 per cent). The 2 who died were 67 and 83 years of age and death occurred on the 17th and 27th days, respectively. Of the 25 who survived, their stay in the hospital was from 2 to 4 months. Five have been followed from 1 to 3 years, 9 from 4 to 12 months, and 11 for less than 3 months. There were 34 patients who were treated by Russell traction from 3 to 15 days and then operated upon. They are included under the analysis of patients treated by internal fixation.

Of the 73 patients operated upon, 68 were treated by internal fixation and 5 by external fixation. The 5 patients treated by external fixation died. Many were 70 years of age and more. While there was no immediate reaction to the operation, infection around the pin sites contributed to their death. Of the 68 patients treated by internal fixation, 34 had been previously treated by Russell traction for 3 to 15 days. Nine of these patients died (13 per cent).

In 7, Moore pins were used; 3 of the patients died. They were 78, 82, and 92 years of age and were operated upon under local anesthesia on the 17th, 7th, and 6th day, respectively. They were all in precarious condition. Of the 4 others, a coxa vara resulted in 3. The object of the operation was to make it possible for the patients to be moved in bed without pain.

Of the 61 patients who were treated with a Smith-Petersen nail with or without the Hawley bar, 12 died, a mortality of 19.6 per cent, and a 12 per cent mortality for the entire group. Four wounds were infected and responded to treatment. In 5, the screws holding the bar to the nail became loose and resulted in a change in the position of the fragments. They were reapplied. Not all of the comminuted fragments were perfectly replaced, but the fixation did hold the major fragments in position with the exception of the 5 cases in which the screws loosened. The displacement of the avulsed lesser trochanter frequently remained unchanged. This was followed with an enormous proliferation of new bone which was contiguous with the shaft and not infrequently accounted for considerable pain.

The periods of observation for the 53 patients who survived their internal fixation is as follows: 1 for 2½ years, 10 for 1 to 2 years, 10 for 7 to 12 months, 9 for 4 to 6 months, and 23 for less than 3 months. Some were homeless and social problems and had to be placed in institutions, from which it would be inexpedient to have them return.

EXTERNAL PIN FIXATION

So much has recently been said about successful external pin fixation in the treatment of fractures that a note of caution must be sounded in the application of this procedure to fractures of the hip. Our experience with external pin fixation has been limited to 1 intracapsular and 5 extracapsular fractures. In our hands the complications encountered have been sufficiently serious to merit critical review.

Infection developed at the site of pin insertions in all of the 6 cases. Five patients died. The infections undoubtedly were contributing factors to their demise. If other surgeons have experienced the same disastrous consequences, we have not found any mention of it in the literature. Of the 5 patients who died, 1 was over 60 years, and 4 over 70. They were all in poor physical condition.

The procedure was undertaken because of the many advantages which the authors attributed to its use. Primarily they claimed that rigid fixation could be obtained by external pin fixation without an incision and thus eliminate an operative wound with damage to the soft tissue, impairment of the blood supply and bony structures. It was also claimed that this method of treatment would appreciably lessen the shock which attends an intra-articular or extra-articular operation; that the procedure was much simpler than an open operation; and that it obviated the use of a plaster spica or traction and thus permitted the earlier use of crutches and appreciably shortened the period of hospitalization.

No difficulty was encountered in properly transfixing these fractures after they had been reduced. There was practically no shock or reaction to this procedure, and it was simpler and less time consuming than an open operation.

The friction of the soft tissues of the thigh against the pins when the patient sank in the mattress or raised himself on a bed pan or turned in bed resulted in an inflammatory reaction about the pins which subsequently became infected. The first site to become infected was usually the uppermost muscular and fleshy part of the thigh. Some of the patients undoubtedly fingered the dressings at the sites of pin emergence. Every effort was made to keep the wounds meticulously clean. The nursing care became a serious problem. The heads of the pins dug into and tore the sheets. The patients were not comfortable. They were reluctant to move and were apprehensive.

The patient (A.S.), who survived, was 57 years of age. He had a transcervical fracture. Under a local anesthesia the fragments were realined by the Leadbetter maneuver. A collodium dressing was applied over the pin sites. The patient was allowed out of bed on the 9th day. One of the pins in the shaft of the femur projected slightly beyond the opposite cortex. An exudate soon appeared at the site of insertion of this pin. Within a few days a tender area of induration was palpable on the inner side of the thigh. He was then kept in bed. With movement this swelling increased in size and was persistently tender. The pins were removed 2 months after their insertion. The pins in the shaft were loose—and with their withdrawal, 2 ounces of pus was evacuated. The 2 pins in the neck of the femur were found to be held rigidly. Within a few days after the removal of the pins the discharge diminished and the wound healed. Eleven months later the fracture was united and the patient discarded his crutches (Fig. 2, a, b, c, d).

In our hands external pin fixation did not simplify the management of fractures of the neck of the femur. Other than expediting the procedure of immediate transfixion and minimizing the amount of trauma in the process of fixation, this method had no advantage over internal fixation. The nursing care was increased, the patients were apprehensive and refused to be ambulatory because of the pain in the region of the pin sites. There was a constant dread of infection because of the exudate which resulted from the friction caused by the movement of the soft tissues against the pins. Under these circumstances the surgeon could not discharge the patient from the hospital with the apparatus for fear of infection. To have transfixed the protruding pins adequately to the soft tissue it would have been necessary to incorporate them in a plaster spica cast which would immobilize the pelvis and both hips. This would be reverting back to the procedure of confining the patient to bed with its potential dangers.

We believe that external fixation for fractures of the hip and intertrochanteric region to be a hazardous procedure and should be reserved for those experienced and familiar with its use.

We do not believe it should replace internal fixation for fractures of the hip.

CONCLUSIONS

The treatment of choice for the intracapsular fractures in the aged and feeble is the immediate insertion of a Smith-Petersen cannulated 3 flanged nail or similar device.

The treatment of choice for the intertrochanteric fractures in the aged is the immediate insertion of a device incorporating the principle of a Smith-Petersen nail and Hawley bar, preferably a Moore-Blount blade plate.

For intertrochanteric fractures in the younger age group bilateral Russell traction suspension has given very satisfactory results, and we see no reason at present to change our opinion.

External pin fixation should not replace internal fixation for fractures of the hip or intertrochanteric region. Other than expediting the procedure of transfixion and minimizing the immediate trauma, it has none of the advantages of internal fixation. It is an extremely hazardous procedure and should be restricted to those who have had experience and are familiar with its technique.

It is our conclusion that the patients who are in poor physical condition on admission have a better chance of survival if they are operated upon immediately rather than waiting to see if their general condition improves. We disagree with the selection of survivals policy in which all patients are treated conservatively for a few days and then the operation is decided upon only for those whom it is expected will survive.

Immediate operation permits early ambulation in bed without pain, reduced incidence of potential complications, and allows early ambulation with crutches.

The use of local anesthesia, focal skin clips, and guide wires, and the three sets of indispensable roentgenograms, to determine (1) the accuracy of reduction and location of the skin clip in relation to the head of the femur, (2) the position of the guide wires, and (3) the position of the nail, will enhance the ability of the surgeon to expedite the proper insertion of the transfixion device.

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INDUCTION EXAMINATION FOR INGUINAL HERNIA

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A LARGE and concentrated experience as a part time surgical examiner in a southern New York induction district, including the largest induction station in the United States, has given me the opportunity of examining many thousands of men, for hernia. This experience has offered an unusual chance to learn many important details in hernia examination together with evaluation of those conditions which simulate or mask hernia or offer problems in differential diagnosis. It is hoped that the observations in this paper may be helpful to others, even if some facts which are generally known are re-emphasized.

Men who have hernias are not acceptable to the armed forces. This article will deal only with examination for inguinal hernia. No distinction will be made between the direct and the indirect. For practical purposes, hernia is diagnosed when a sac can be made to protrude beyond an external ring by increased intra-abdominal pressure produced by any technique.

Surgeons usually develop individual methods for the examination for hernia. Consultation among surgical examiners at the induction station has been encouraged so that the establishment of the presence or absence of hernia in a doubtful case is made only after an examination by several surgeons.

The pressure of work at an induction station becomes very great, so that it is important to develop system in the examinations. The men strip completely, line up in groups of 6 and inquiry is made whether any man complains of a hernia. A group request is made for each candidate to turn his head to the right, place a hand over his mouth, and cough or strain when instructed to do so.

Stance of the examinee. The man should face the examiner and stand up straight and with the feet flat on the ground and about one foot apart. The examination is frequently uncomfortable, ticklish, or psychically disagreeable to the candidate, with resulting lack of co-operation. This may be evidenced by laughter, rigidity, flexion of the knees, standing on one foot or the toes, pulling away or turning the body. Reassurance and gentle examination usually correct these conditions.

From the Armed Forces Induction Station, Grand Central Palace, New York.

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TECHNIQUE OF THE EXAMINATION

Inspection may show swelling in the inguinal or scrotal regions. Coughing or straining may elicit a bulge, but this does not necessarily mean the presence of hernia. If a sizeable bulge disappears when the man lies down the surgeon presumes that a mass has been reduced which is probably hernial in origin.

Palpation should be gentle at all times. Too much stress has been laid on "impulse on coughing" alone as diagnostic of hernia. Such an impulse may occur with or without invagination of the scrotum and without the presence of a hernial sac. But an impulse which transmits to the examining finger a circumscribed, soft, compressible mass indicates the presence of a sac. Frequently a hernial sac does not have an impulse either because of the nature of its contents or because of surrounding adhesions. The three middle fingers placed over the external ring may feel a definite impulse or "trickle" or "thrill" when the examinee coughs or strains. These signs are presumptive but not positive evidence of hernia. Supplementary examination is made with the ungloved, tactile surface of the index finger on which the nail has been cut short. The left finger is used for the left side and the right for the right side. The dependent part of the scrotum is invaginated up to the pubic spine, but not into the external ring. The pubic spine should be felt at all times as an identifying landmark. A small and elusive sac may be demonstrated by the preliminary jumping, coughing, straining, or squatting of the examinee, or by finger pressure downward over the inguinal canal. One of these methods may help to elicit the sac when all the others fail. Frequently coughing alone does not bring down a sac. In such an instance, it is surprising how often one of the other methods will demonstrate the sac. Straining especially is helpful in revealing a hernia. The value of straining to demonstrate the presence of a hernia has been so impressive that its routine adoption is recommended. Straining produces maximum muscle play and is associated with a more prolonged intra-abdominal pressure than is coughing.

Many cases in which the external rings were small and tight and in which straining alone elicited large scrotal hernias with thin-walled sacs were noted. It has also been observed that an inguinal truss will very often prevent the descent of a sac and it can be demonstrated only after repeated and prolonged examination by one or several of the methods which have been suggested. Examination in the squatting position is a good accessory technique in doubtful cases. A sac may be demonstrable only when the man stands up but not when he lies down, and vice versa. Dr. John G. Muccigrosso, one of the surgical examiners, has demonstrated a method of detecting a small sac which has been very helpful. The selectee is asked to lie on his back and cough several times. The fingers of one hand are then quickly placed on the abdominal wall over the internal ring with firm, fixed downward pressure. The examining finger of the other hand then invaginates the scrotum up to the pubic spine. An incarcerated, trapped globular sac can be felt just beyond the external ring. At times such a sac cannot be demonstrated by any other technique.

FACTORS WHICH INTERFERE WITH HERNIA EXAMINATION

1. Improper stance of the examinee has already been discussed together with measures for its correction.

2. Rough examination is inexcusable. A painful examination produces all the factors which contribute to an improper stance and lack of co-operation.

3. A shriveled, tight or small scrotum may easily mask a hernia, especially since it may be difficult to invaginate. Such a scrotum predominates in the colored and yellow races. Very often it is produced by cold, nervousness, or anxiety.

4. Excess pubic, scrotal, or cord fat often contribute to obliterate normal landmarks, such as the pubic spine and the pillars of the external ring. Proper invagination of the scrotum may be difficult and even when accomplished, the fat must be distinguished from a hernial sac. Patience may be required to demonstrate the external ring.

5. As to malingering, a man is malingering when he protests and insists that he has a hernia, knowing that he has none. He is trying to evade service in the armed forces. Some of the devices which he uses are a prompt lamentation about his "hernia," a statement that many doctors have concurred in this diagnosis, an exaggerated complaint of pain in his groin with unusual reference, alleged inability to exercise or lift weights, and frequently the exhibition of an inguinal truss which is apt to be new. This last should always arouse suspicion in the examiner. A positive statement that there is no hernia, after an examination by several surgeons, usually convinces the selectee that he cannot "put it over."

CONDITIONS CONFUSED WITH INGUINAL HERNIA

1. A relaxed inguinal ring is an external ring which easily admits a finger tip and in which an impulse can easily be felt on increased intra-abdominal pressure. Along with this impulse it may be possible to feel what is interpreted as a sac which does not protrude beyond the external ring. Some physicians prefer to call such a condition an "incomplete" hernia or bubonocele, especially if, on coughing, there is a visible bulge in the region of the inguinal canal. In the strict anatomical sense, it might be argued that a careful dissection of the inguinal canal would expose a hernial sac. For practical purposes, however, such a condition is not considered an "army" hernia, even though the potentiality of subsequent development of a hernia, as defined in the early part of this paper, is fully recognized.

2. Varicosities of the cord usually form a mass, especially when one stands, and they almost always continue downward to form varicoceles of varying sizes. The varicosities may block the external ring and give the impression of a hernial sac, especially if coughing and straining impart to the examining finger the sensation of a "trickle" or "thrill" which is so often diagnostic of a hernia with a thin walled sac. In the case of varicosities, the "trickle" or "thrill" is produced by sudden increased intravenous pressure brought on by coughing and straining. The trick in differential diagnosis is to make sure that the examining finger is on the pubic spine and then to use the same finger to push the cord and varicosities laterad. The same procedure can be carried out with the man lying on his back. This empties the veins. The external ring can then be felt and a proper appraisal of the presence or absence of hernia can be made.

3. Lipoma of the cord is frequent in the obese. The mass varies in size and usually protrudes beyong the ring. It is attached to the cord by either a broad or a very thin base. The summit of the lipoma is frequently movable from side to side. The mass has no expansile impulse when examinee coughs, and it can be pushed aside with the cord to demonstrate that there is no connection with the inguinal canal.

4. A thickened cord frequently gives the impression of a mass descending from the inguinal canal. It may accompany obesity, unusually

large genitalia, or it may be the end-result of an inflammatory condition of the cord and testis. The thickened cord can be pushed aside with the examining finger, which should in every case first locate the pubic spine.

5. Properitoneal fat can be felt as a fat tab within the inguinal canal. It is usually situated mesially, it may be movable, and there is no enlargement or expansile impulse when one coughs.

6. Hydrocele of the cord or tunica vaginalis is circumscribed, elastic or very tense, and such a swelling does not reduce into the peritoneal cavity when it is squeezed or when one lies down. It usually transilluminates.

7. Split superficial fascia often creates the impression of a very large external ring. Coughing or straining may force a rounded mass through the hiatus in the superficial fascia. This mass is usually muscle and it must not be mistaken for a hernial sac. Proper palpation of the pubic spine by the examiner running the finger mesial to the cord helps to locate the true external ring.

8. Muscle bulge in the inguinal region is usually very apparent on inspection. It is caused by a weak or attenuated conjoined tendon or internal and external oblique. The external ring may be relaxed or tight, but a hernial sac cannot be demonstrated.

9. A mobile or undescended testis. A normally situated testis may temporarily be dislocated up into the inguinal canal by a strong cremaster reflex. This gives rise to a soft mass in the inguinal region. A pubic or inguinal undescended testis produces a similar mass. It must not be confused with a hernial sac, even though the testis blocks the external ring. A testis is smooth, elliptical, quite tender, and it has a solid consistency.

THE LOCATION OF THE SAC WITH RELATION TO THE CORD

Although the usual position of the sac of an indirect inguinal hernia is mesial and slightly posterior to the cord, the sac has been found in every position around the clock. It is frequently so laterad that it is missed by a casual routine examination.

SUMMARY

Observations have been made on the examination and diagnosis of inguinal hernia based on a large and concentrated experience among selectees in the largest induction station in the United States. Many thousand men were examined. This experience has served to demonstrate pitfalls in diagnosis, even in well trained and careful hands. These pitfalls have been enumerated. Various helpful techniques for examination have been discussed. Conditions which may be confused with or hinder the examination for inguinal hernia have been evaluated and suggestions have been made for differential diagnosis.

A MESENTERIC POUCH HERNIA SIMULATING PARADUODENAL HERNIA

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INTRA-ABDOMINAL hernias are of such rarity that they often escape consideration in the differential diagnosis of acute or chronic intestinal obstruction, or recurrent slight digestive symptoms. However, since an intra-abdominal hernia may possibly be responsible for such symptoms and, in view of the interesting clinical characteristics of a case which was tentatively diagnosed before operation, it seems worth while to report it.

A twenty-seven year old sergeant was admitted to Hoff General Hospital on November 17, 1942, with the chief complaint of severe abdominal pain of 2 hours' duration. The family history was of no significance. The past medical history was essentially negative except for a history of frequent attacks of asthma between the ages of 5 and 14 years.

In August, 1942, the patient was hospitalized in an Army hospital for a period of 5 days for a very severe attack of generalized abdominal pain that came on suddenly after a bowel movement. There was no history of radiation of the pain, no nausea or vomiting, and, after 30 minutes, the pain gradually subsided. Three weeks later a similar severe attack occurred which lasted 10 minutes, but which was followed by a feeling of heaviness in the lower abdomen that persisted until the onset of the present attack. This attack likewise came on suddenly. The patient stated that the pain was constant and severe although at times it became worse. It was confined mostly to the lower midabdomen. Again there was no nausea or vomiting or radiation of the pain although there was some complaint of a lower lumbar backache. No history of diarrhea or of blood or mucus in the stools was elicited in connection with any of the attacks. There were no urinary symptoms.

When seen on November 17, 1942, approximately 2 hours after the onset of pain, the patient was observed to be a well developed and nourished soldier of medium frame who was lying in bed apparently suffering from considerable abdominal pain. The temperature was 98.6 degrees F., the pulse regular and 84 beats to the minute, and the blood pressure was systolic 150 and diastolic 90. The general examination was essentially negative except for a moderate degree of facial acne and the abdominal findings as follows: There was considerable abdominal distention and on palpation moderate generalized tenderness was present which was more marked just below the umbilicus. There was no rigidity or rebound tenderness. No palpable masses or evidence of a fluid wave could be found. On auscultation, peristalsis was found to be hyperactive.

The blood count taken on admission showed 13,400 leucocytes per cubic millimeter with 90 per cent neutrophils. The urinalysis was essentially negative.

With these clinical findings a period of observation was decided upon and the tentative diagnosis was that of a possible volvulus due to the dramatic, abrupt, severe onset which characterized each attack. An enema was given to the patient, without results. The severe pain continued for approximately 12 hours during which time there was no temperature elevation, no nausea or vomiting, and the abdominal physical findings did not change. Following this there was a gradual improvement objectively and subjectively, and 24 hours after the onset of the attack the blood count showed 11,150 leucocytes per cubic millimeter with 75 per cent neutrophils. On November 22, 1942, it was possible to proceed with appropriate roentgenological studies of the gastrointestinal tract and one of us (A. J. P.) and Captain Robert G. Freeman carried out these examinations. On giving the patient barium by mouth a normal stomach and duodenum were observed. However, interval films taken at approximately 30 minute periods for 6 hours showed the small intestines to be coiled in a well defined circular mass suggesting the possibility of an intra-abdominal hernia, probably paraduodenal, from the roentgenological standpoint (Fig. 1). A barium enema showed no abnormalities.

With the patient's history and the x-ray findings a tentative diagnosis of paraduodenal hernia was made and surgery was advised.

On December 14, 1942, spinal anesthesia being used, a left rectus incision was made, and when the abdominal cavity was opened and the omentum and transverse colon were elevated, a large, round, thin walled sac about 8 inches in diameter presented itself in the midline below the transverse mesocolon (Fig. 2).

The sac appeared comparatively avascular and coils of small intestine could be clearly seen within it. On exploration the colon was observed to be in its normal position and about 3 feet of the terminal ileum was in the free abdominal cavity. On elevation of the sac it was found to be lying free in the abdomen except for its attachment near the duodenojejunal juncture. On retracting the sac to the right, the duodenojejunal juncture as well as the mouth of the sac could be seen (Fig. 3). An abnormally broad and thickened duodenojejunal fold was present extending from the anterolateral surface of the upper 3 inches of the jejunum to the posterior parietal peritoneum to the left of the jejunum and serving to bind down the proximal 3 inches of the jejunum. Directly beneath the lower horizontal margin of this fold was the mouth of the hernia with the jejunum entering it, after making a very short loop, and with the ileum leaving it.

The duodenojejunal fold was severed just lateral to the jejunum and, by gentle traction on the ileum, the sac emptied itself readily. On insertion of the index finger into the mouth of the sac the opening was found to course through the mesentery of this relatively immobile loop of jejunum and on insertion of the finger fully it presented itself within the sac to the median side of this loop. The opening through the mesentery was approximately 4 centimeters in diameter, and it was observed that the neck of the sac was below and free from the duodenum and anterior to the mesenteric vessels which were not involved in the sac wall (Fig. 4). The fundus of the sac was opened and it was

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ound to consist of two layers of thinned out peritoneum, thus proving conclusively that the walls of the sac represented a pouching in the mesentery of the proximal jejunum. The mesentery to the small intestine was otherwise normal.

The sac was then everted through the opening in the mesentery, the excess portion excised, and the mesentery reconstructed, completely obliterating the sac. The wound was then closed in the usual manner.

The patient had an uneventful convalescence and returned to general military duty March 10, 1943.

ETIOLOGY

In 1786 Neubauer described the first recorded case of duodenal hernia although it was not until 1857, when the work of Treitz appeared, that the subject of retroperitoneal hernia really became existent. Treitz gave a good description of the fossae about the duodenojejunal juncture, stated their probable origin, and was of the opinion that such hernias occur in fossae that are normal but by no means always present.

In a classical study of the subject written in 1899, Moynihan described 9 "duodenal fossae" in the vicinity of the junction of the duodenum and jejunum, some of which are frequently found while others are very rare. He described right and left duodenal hernias and expressed the belief that an increase in intra-abdominal pressure started the formation of a hernia provided the proper fossa was present and a loop of small intestine became engaged in the fossa.

He assembled 57 cases of so called left duodenal hernia from the literature and was of the opinion that they arose from the paraduodenal fossa or fossa of Landzert which always has the inferior mesenteric vein, and at times the left colic artery, in the anterior fold of the fossa. He found the following characteristics invariably present with a left duodenal hernia: (1) the inferior mesenteric vein and usually the left colic artery are present in the neck of the sac; (2) the hernia projects itself to the left toward the descending mesocolon, or toward and into the transverse mesocolon, or both; (3) the hernia contents has two layers of peritoneum anteriorly and one layer posteriorly.

Regarding right duodenal hernias, of which he collected 14 cases, Moynihan was of the opinion that they usually developed from the mesentericoparietal fossa (fossa of Waldeyer) or the parajejunal fossa. The mesentericoparietal fossa was first described by Waldeyer, and Moynihan states that its most usual position is in the first part of the mesojejunum, directly behind the superior mesenteric vessels and immediately below the duodenum. To quote Moynihan: "The fossa has its orifice looking to the left, its blind extremity to the right and downward. In front it is bounded by the superior mesenteric artery and behind by the lumbar vertebrae. The peritoneum of the left leaf of the mesentery lines the fossa, that of the right covers the blind end, and is then continued directly into the posterior parietal peritoneum." Moynihan considered the parajejunal fossa as being practically the same as the mesentericoparietal fossa except that the first one-half to 4 inches of the jejunum is adherent to the posterior abdominal wall. Of the 14 cases of right duodenal hernia found in the literature by Moynihan, 7 had the adherent jejunum. Broesike, who originally described the parajejunal fossa, found that on lifting up the first free portion of the jejunum a fossa could be seen behind and to the right of it, bounded by a sharp peritoneal fold. A finger introduced into the fossa progressed between the mesentery and the posterior parietal peritoneum. Moynihan found several features invariably present in right duodenal hernias: (1) at first in all cases the sac occupies the right half of the abdominal cavity, lying behind the ascending and transverse mesocolon; (2) the orifice is behind and to the left of the sac on the lumbar vertebrae; (3) the superior mesenteric artery or a continuation of it, i.e. the ileocolic artery, lies in the anterior margin of the sac.

In 1920 Andrews dissented from the then prevalent opinion that small fossae about the duodenojejunal juncture are the starting point of these hernias. He presented evidence to support his thesis that "duodenal hernia is a congenital anomaly due to imprisonment of the small intestine beneath the mesentery of the developing colon." If rotation of the umbilical loop is not carried to completion, he stated that a right duodenal hernia would be produced. To quote, "The caecum then would not lie superior to the small intestines and, as it grew to the right, the small bowel would be caught in its mesentery, and finally when its mesentery became adherent to the right posterior abdominal wall, the imprisonment would be complete. The superior mesenteric and ileocolic artery would lie in the free edge of the neck of the sac." Andrews regarded left duodenal hernia merely as a more pronounced degree of the same process. To quote Andrews again, "Now let us suppose that no rotation of the loop occurs, or perhaps there is a little in the wrong direction. The caecum would then lie to the right of the midline in the lower abdomen. The colon runs straight to the rectum. As it gains in length, it forms a loop, and when the caecum seeks its normal primitive position in the left upper quadrant, the small bowel is caught beneath the mesentery of the descending colon. The inferior

mesenteric artery would then lie in the free edge of the sac neck and the vein would lie above, thus making the vascular arch of Treitz, which has been noted in most of the hernias." This conception has been accepted by many authors.

In 1935 Callander, Rusk and Nemir reported a case of so called left duodenal hernia. In the embryological discussion they brought out convincing evidence that this type of large hernia is not a result of incomplete or malrotation but rather the result of invagination of an area of the descending mesocolon medial to the ascending branch of the left colic artery and inferior mesenteric vein by the jejunoilcum while the descending colon is mobile and has not as yet fused with the primitive posterior parietal peritoneum. From the embryological and anatomical standpoints they were of the opinion that the name of this type of hernia should be changed to "hernia into the descending mesocolon." They further mentioned right duodenal hernia and suggested that it be called "hernia behind the ascending mesocolon."

In the case reported here there was no evidence of incomplete or malrotation, and outside of the hernia itself the only abnormal finding was a broadened and thickened duodenojejunal fold. As previously mentioned in the description of the findings, the sac consisted of two thinned-out layers of peritoneum and was entirely free in the abdomen except for its "pedicle" near the duodenojejunal juncture. Furthermore, although the orifice of the sac was situated to the left behind the proximal jejunum, the superior mesenteric vessels were entirely behind the neck of the sac. Therefore, the qualifications for a right paraduodenal hernia are not met, and it must be considered to be a mesenteric pouch hernia arising from the mesentery to the proximal jejunum.

Embryologically[1] it is believed that this hernia developed as a result of a preternaturally long prearterial mesentery in the region of the proximal jejunum. At the completion of the second stage of rotation it is logical to conclude that one or more loops of small intestine became engaged in a pouch formed by the preternaturally abundant prearterial mesentery to the proximal jejunum and became incarcerated as a result of early fusion of the upper jejunum as represented by the abnormally broad and thickened duodenojejunal fold found at the time of surgery. Then as a result of growth in length and size of the small intestine the hernia enlarged.

[1]We are indebted to Doctors C. Latimer Callander and John B. de C. M. Saunders for their helpfulness in the embryological explanation of the hernia reported here.

Fig. 1. Anteroposterior and lateral roentgenograms taken 1 hour after barium by mouth, showing the small intestines coiled in a well defined circular mass.

SYMPTOMS

Mesenteric pouch hernias are reported much less frequently than paraduodenal hernias. However, as the hernia reported here had its origin high in the mesentery to the small intestine in the paraduodenal region and exhibited the same symptoms as might be expected of a paraduodenal hernia, it seems fitting to include this case with paraduodenal hernia in a general discussion of symptoms.

The hernia described here gave a very suggestive history of a temporary volvulus on 3 different occasions. In the literature there are cases reported in which repeated bouts of intestinal obstruction occurred over a period of years before surgical intervention was carried out or in which the first attack of obstruction necessitated immediate surgery. Other cases have been reported with vague, slight gastrointestinal distress. However, the majority of the reported cases were found either at autopsy or upon abdominal surgical intervention for some other condition with no known past history of gastrointestinal distress.

In all but a small minority of the reported cases the herniation of the small intestine has been total or subtotal and, although the proportion is smaller than we would expect, a soft, palpable tumor has been found in some cases. These cases have usually been misdiagnosed as ovarian, pancreatic, or mesenteric cysts. Andrews has reported a case in which a large palpable mass appeared only at times. As here noted no mass was palpable in our case.

If present, such a mass may be found to be more in the superior, middle, right or left ab-

Fig. 2. Appearance of hernia after the abdomen was opened through a left rectus incision and the omentum and transverse colon were elevated.

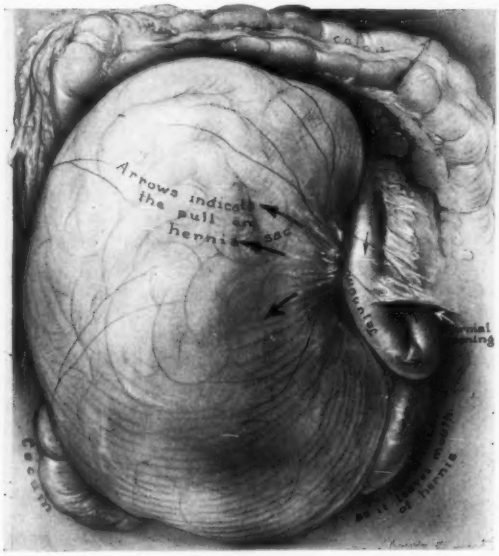

Fig. 3. Upon the elevation and retraction of the hernia sac to the right, the hernial opening is seen with the abnormally broad and somewhat thickened duodenojejunal fold.

domen depending upon the type of anomalous development that is responsible for its formation. Percussion should give a resonant note and on auscultation gurgling peristalsis may be heard.

ROENTGENOGRAPHY

Hernias occurring near the duodenojejunal juncture have very infrequently been diagnosed before operation. It is quite probable that Kummer, in 1921, first visualized such a process, after finding a hernia during surgery and then studying roentgenograms of the barium filled loops after operation. Taylor, Case and Upson, and Exner subsequently recognized paraduodenal hernias before operation. Alexander reports 5 roentgen "impressions" without information as to operative confirmation. A complete summary of the literature is admirably provided by Exner.

From the findings of these writers, and the entirely consistent observations in our case, it is apparent that an accurate diagnosis is obtainable roentgenographically. There are two essential factors, namely: that the possibility of encountering such a hernia be remembered and that an adequate roentgenographic study be completed. Such a study includes interval films and fluoroscopy for a variable period of from 6 to 48 hours after barium orally. Lateral films and studies in the upright position contribute greatly to the sum of information obtainable.

The case here reported admirably emphasizes the characteristic findings. There was primarily a clumping of small bowel loops as if in a sac (Fig. 1), and these could not be separated or displaced by palpation. Their relationships remained essentially unchanged upon change of position of the patient. Lateral upright films demonstrated this pocketing with marked clarity (Fig. 1, b). There was a definite absence of small bowel loops in the pelvis and deep flanks. With such a gathering of the greater portion of the small bowel into a sac, intestinal motility was decreased and the barium meal progressed more slowly than usual.

Case and Upson stated that whenever the duodenum goes directly to the right and thence into the jejunum without the normal swing to the left, a paraduodenal hernia should be suspected. Although not true in our case, the mass may displace the stomach or colon. Manual pressure may be transmitted as a fluid wave.

Roentgenographically the confusing conditions include peritoneal adhesions and a congenitally short mesentery (Golden). In the former a more

diffuse pattern is to be anticipated with sharper angulations and segmentations of the involved loops. Palpation, normal progress of the meal, and change in position of the loops in decubitus films should eliminate a short mesentery. Various pelvic masses may displace the small bowel upward, but the lower margin of the barium filled loops will be convexly deformed. Exner lists such conditions as a full bladder, distended large bowel, uterus, pelvic tumor, or an unusual amount of fat.

Presented with the unusual finding of a smoothly outlined, clumped small bowel pattern, and with confirmatory decrease in mobility and motility, the diagnosis of a hernia in the region of the duodenojejunal juncture should be suggested. Only by complete so called "small intestinal" studies can the proper conclusion be obtained.

TREATMENT

The treatment of hernias occurring about the duodenojejunal juncture is surgical. In recent years as a result of the earlier recognition and better understanding of congenital anomalies, the mortality rate, although still high, has been improved a great deal. Obviously the operation would be more easily accomplished and attended with less risk if carried out electively rather than as an emergency procedure in the presence of an obstruction.

From an operative standpoint the procedure may be simple, as in the case reported here, or very difficult. In some postmortem cases, in which the hernia was discovered as an incidental finding and in which there was no known history of gastrointestinal distress, it has been found impossible to reduce the hernia surgically without causing irreparable damage. This has also been found true in a few of the operative cases reported and has been due to dense adhesions about the mouth of the sac, a small nondilatable opening of a left paraduodenal hernia, or the matting together of the incarcerated small intestine by fine adhesions. In the case of a left paraduodenal hernia the inferior mesenteric vein and usually the left colic artery are present in the anterior portion of the neck of the sac and the former is usually close to the margin and courses medially in such a way that it may preclude making an incision in the neck of the sac. In a right paraduodenal hernia one is more fortunate. Because of the relationship of the vital structures, the neck of the sac can usually be enlarged by incision, if this is necessary.

In the case reported here, after reduction of the small intestine, the sac of the mesenteric pouch hernia was excised and the mesentery was reconstructed. However, with the usual right or left paraduodenal hernia, it is obviously not possible to excise the sac, and closure of its neck has proved satisfactory.

Fig. 4. Diagrammatic drawing to show the posterior relationship of the mesenteric vessels to the neck of the hernia sac.

If obstruction is present and it is impossible to reduce the hernia, a small opening in the fundus of the sac should be made in an avascular area, a Witzel type of enterostomy carried out, and the opening in the sac closed tightly around the tube. If the patient is operated upon electively and it is found that it is impossible to reduce the hernia, one's judgment as to the danger of future obstruction would undoubtedly guide the procedure. Thus, with no previous gastrointestinal history, it is our opinion that the hernia should not be disturbed. However, if attacks of obstruction have occurred, a lateral enteroanastomosis would be indicated, provided enough ileum is present in the free abdominal cavity to carry out the procedure through a small opening in an avascular portion of the fundus of the sac. Following this it would, of course, be important to close the sac just proximal to the anastomosis. If no loop of ileum is available it is conceivable that it might be possible to do an ileocolostomy, although the risk of the procedure would be greater.

SUMMARY AND CONCLUSIONS

1. A mesenteric pouch hernia occurring in a soldier with a history of three attacks suggestive of volvulus is described. The preoperative diagnosis based on the roentgenographic findings was probable paraduodenal hernia.

2. Because of the origin of this hernia near the duodenojejunal juncture, it is discussed with paraduodenal hernias from the standpoint of etiology, symptomatology, roentgenography, and treatment.

3. While many of these rare hernias are entirely asymptomatic, they may cause acute or chronic intestinal obstruction or recurrent slight digestive symptoms and should always be considered as a possibility in the differential diagnosis.

4. If immediate surgery is not mandatory and the patient can be seen in an interval free of acute obstructive symptoms, roentgenographic studies by the so called "small bowel" technique are indicated. Thus, a correct preoperative diagnosis is to be anticipated.

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REPAIR OF AN AVULSED SCROTUM

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REPAIR of injuries to the scrotum and penis, resulting usually from industrial accidents, is not a common problem, but when the necessity for such repair does arise a satisfactory solution is of the utmost desirability. These injuries and their sequelae are most disturbing to the patient and present to the surgeon a reconstruction problem which demands patience, persistence, and understanding.

Owens, in summarizing the reports which have appeared in the literature on penile and scrotal repair, states that there have been only 13 reports of instances of avulsion of both penile and scrotal skin, and a total of 34 reports of loss of the skin of either the penis or scrotum. Gibbs was the first to report (in 1855) on the complete destruction of the penile and scrotal skin and one other report appeared in 1881. These 2 were the only reports on this subject which appeared in the medical literature prior to 1900. The increase in the number of such reports since 1900 may be due to the fact that the increasing use of machinery has been responsible for an increasing number of such accidents, as Owens points out.

Up to the present, the method most frequently employed for covering denuded testes has been to bury them in pockets formed by undermining the skin and subcutaneous tissue on the thighs. This method has been described by Cottle and modifications of the method by Wood, Robertson, and Owens.

In the case reported by Cottle the entire scrotum and left testicle were torn off as well as all of the skin and fascia of the penis. The method of repair was as follows: An external urethrotomy was performed and a catheter was inserted. A wide area of skin together with the superficial fascia was dissected free from the inner aspect of the right thigh, thus preparing a pocket for the remaining denuded testis and the spermatic cord. A tunnel into which the penis could be placed was then prepared by lifting up the skin and superficial fascia over Poupart's ligament, and an opening was cut at the distal end of the tunnel and sutured to the collar of foreskin. After a period of 5 weeks, healing was nearly completed and the patient was able to urinate without difficulty. It was also possible for erection to occur. A plastic operation to free the penis was then performed in two stages. In the first stage, a flap of skin and superficial fascia was freed below the penis and sutured around it, a broad pedicle being left to maintain the flap's blood supply. In the second stage, 2 months later, this pedicle was severed. The result was a completely covered penis.

In the case reported by Wood the patient had lost the entire scrotum, the left testis, and the skin of the penis. The remaining testis and cord were covered by means of skin flaps cut free at Poupart's ligament and extending 3 inches below. The free ends of these flaps were brought together and sutured. The testis was placed underneath the flaps and they were secured at the upper and lower borders. The penis was covered by means of numerous small skin grafts. The end-result was a satisfactorily covered penis and a nonpendulous covered testis.

Owens reported the case of a man who had lost all the skin from the penis and scrotum as the result of an accident which occurred while the patient was working with a tractor. Since the testes were freely movable and could be widely separated, the skin and subcutaneous fat along the medial aspect of each thigh was dissected free and small pockets were formed between the skin and underlying fat and the fascia. The testes were placed in these pockets and the top of each pocket was closed. The penis was covered by means of a skin graft which was taken from the inner surface of the right arm. This procedure afforded satisfactory covering of both the penis and the testes. From the cosmetic point of view,

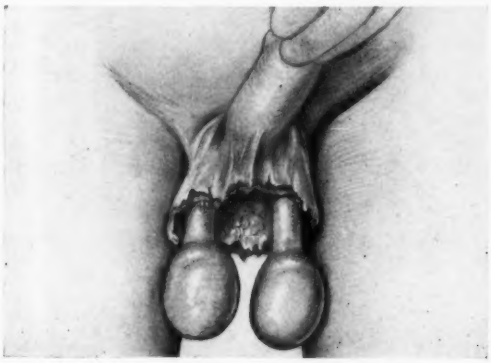

Fig. 1. Extent of injury: scrotum avulsed, testes exposed, skin of penis intact.

Fig. 2. Repair, stage 1: formation of pockets on thighs and insertion of testes.

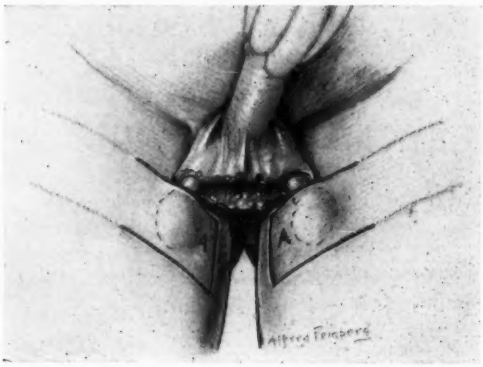

Fig. 3. Repair, stage 2: formation of flaps by medial incisions, *A*, connecting upper and lower incisions in stage 1.

however, the repair was not entirely successful since a scrotum or scrotum-like covering for the testes was not produced. The possibility of remedying this condition was suggested to the patient but he "was not even remotely interested" in a further operation.

Observations indicate that the imbedding of the testes in the thighs and the resultant abnormal anatomic appearance have undesirable physiological and psychological effects. The physiological disadvantages include the possibility of pain because of maintained pressure on the testes as well as tension on the cord resulting from the close quarters afforded by the pockets and their anatomical location; and the possibility that maintenance of the testes at body temperature may result in sterility. In addition, patients who have undergone such repair feel definitely inferior and are loath to disrobe when other men are present. Such psychological conditioning should be avoided if it is at all possible to do so. In view of these disadvantages, another more desirable procedure was sought and a method of repair evolved which, it is believed, offers a more desirable and satisfactory solution to the problem of scrotal and penile denudation.

In an attempt to repair a partially denuded penis or testis, it must be kept in mind that the procedure involves certain basic requirements which are common to the repair of any denuded surface defect, namely, the injured surface must be properly débrided and cleansed and skin grafting must be performed in the usual manner. The method of repair, involving these basic re-

Fig. 4a. Repair, stage 2: union of flaps by suturing in the midline.

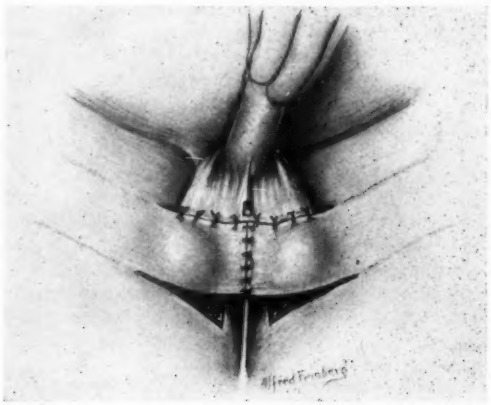

Fig. 4b. Repair, stage 2: upper border of united flaps sutured to skin of scrotal remnant at the base of the penis, *B*.

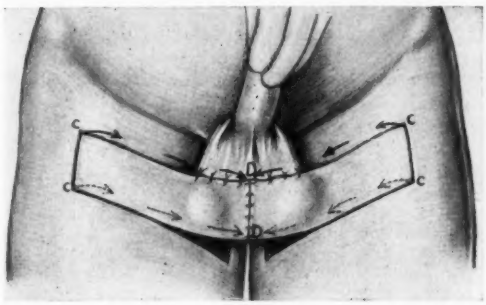

Fig. 5.a, left. Repair, stage 3: united flaps freed by lateral incisions, *C*, connecting upper and lower incisions made in stage 1; cut ends sutured behind the testes in the midline, *D*; upper posterior border of flaps sutured to skin of scrotal remnant at perineal-scrotal juncture. b, right, formation of closed sac by suturing of lower free borders.

quirements and employed for the repair of partial destruction of the penis, loss of one testis, part of the scrotum, and a portion of the penile urethra, was recently described by me. In this earlier case, a skin flap from the thigh was used to cover the remaining (right) testis and the scrotal defects. A tube was constructed from the skin of the thigh and sutured into the penile defect as a connecting link between the two remaining portions of the penile urethra. In the present case, the circumstances are as follows:

CASE REPORT

In October, 1938, a 33 year old factory worker was brought into the hospital on account of a scrotal injury inflicted when his clothing was caught by a rotating wheel. (This was the 4th case of scrotal avulsion to come to our attention in the past 25 years.) The injury consisted of an avulsion of the scrotum with complete denudation of the testes. The skin of the penis was left intact (Fig. 1).

The reparative process was instituted with careful débridement of the traumatized area and cleansing with soap and water alone. In the first stage of the reparative process, an incision was made through the skin and subcutaneous tissue just below and parallel to Poupart's ligament, on both thighs. A second incision was made, on both sides, well below and parallel to the first incision. The skin and subcutaneous fat between the two parallel incisions on each thigh was dissected free from the underlying deep fascia to form pockets. A layer of vaseline gauze was placed on the floor of the pocket, and each testis was then placed in the pocket of the corresponding thigh on the layer of vaseline gauze (Fig. 2). Vascularization between the tunica vaginalis of the testis and the overlying flap could then take place, but not between the testis and the underlying fascial tissues.

Two weeks later the second stage was performed. At this time, an incision was made on the medial aspect of each thigh, connecting the upper and lower incisions made in the first stage (Fig. 3). The free ends of the two flaps thus formed were sutured together in the midline (Fig. 4a), and the upper free border was next sutured to the skin of the scrotal remnant at the base of the penis (Fig. 4b).[1] The testes were kept in approximately the same position as before.

The third stage was performed 2 weeks after the second stage. An incision was made on the outer aspect of each thigh uniting the upper and lower incisions. These cut ends were then brought together behind the testes, thus encircling them, and then sutured. The upper free border was sutured to the adjacent skin of the scrotal remnant at the perineal-scrotal juncture thus forming an open sac containing the testes, with the opening directed downward (Fig. 5a). The next step was to close this sac by suturing the lower free borders together, thus affording a permanent, pendulous, normal appearing covering for the testes (Fig. 5b).

The large granulating areas left on each thigh were covered with vaseline gauze and later successfully covered with half-thickness grafts.

The patient has been followed for the past 4 years. The end-result of the reparative process has been the provision of a normal appearing scrotal sac (Fig. 6). The patient has a well balanced mental outlook and is happily married.

The reparative method described in this report has afforded a scrotal sac which it is difficult to differentiate from a normal scrotum. The normal scrotal responses to changes of temperature occur

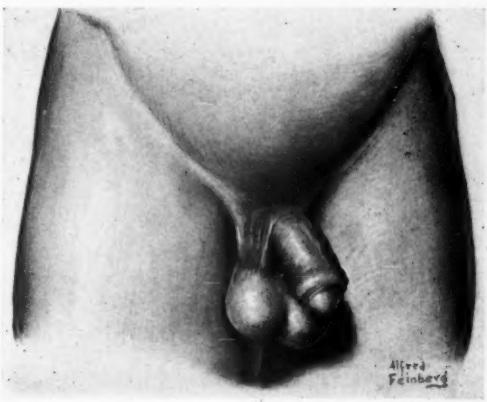

Fig. 6. End-result: a normal appearing scrotal sac.

in the reconstructed scrotum. There is every reason to believe that the physiological function of the testes has not been impaired, and that psychological scarring, as often evidenced by feelings of inferiority and inadequacy, has been avoided.

SUMMARY

The problems involved in repair of scrotal and penile denudation are discussed and methods previously used are briefly described.

A method resulting in restoration of a normal appearing scrotal sac in a patient with avulsed scrotum and completely denuded testes is described.

Attention is called to the physiological and psychological benefits to the patient which result from restoration of a normal scrotal sac.

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A THREE PIN METHOD FOR TREATMENT OF SEVERELY COMMINUTED FRACTURES OF OS CALCIS

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THE end-results of treatment of fractures of the os calcis often leave much to be desired. The common disabilities frequently seen are pain in the heel, persistent swelling and edema of the foot, flat foot, and arthritis of the subastragalar joint. The fact that many methods of treatment are in vogue at the present time indicates that no procedure is satisfactory in every case.

Boehler demonstrated the importance of restoring the tuber joint angle by instituting skeletal traction, and he improved the outcome. Nevertheless, in many cases with apparent anatomical restoration, function has been poor. In fact, certain authors recommend that triple arthrodesis should be employed routinely as soon as the initial swelling has subsided or as soon as the fracture has partially consolidated.

More recently an attempt has been made to secure perfect reduction by methods similar to Boehler's, but so to fix the fragments that motion of the ankle and subastragalar joints could be begun immediately. The rationale of this advance is based upon the thought that freer motion at the joint might prevent the development of adhesions and might also mold smaller fragments in the joint into their proper positions.

Cox has recently developed such a method.[1] He devised a very convenient traction apparatus consisting of a leather and sponge-rubber cuff which laces upon the lower leg. This device provides counter traction against which a pull can be made through a transverse pin in the os calcis. The reduction is performed with the patient upon his abdomen, the foot being in a most convenient and accessible position. The reduction is completed according to the principles laid down by Boehler after which a Steinmann pin is driven from the posterior aspect of the heel across the fracture site in a sagittal direction. The transverse pin is then removed and a slipper cast is applied incorporating the extending portion of the sagittal pin. This method has the advantage of permitting free ankle and subastragalar motion, early ambulation, and free knee motion.

In April, 1942, the author began to use Cox's method of sagittal pin fixation with some modifications. As the Cox apparatus (traction device) was not available, the Bell table was used instead. The reduction was performed with the patient upon the abdomen. It was my impression that more effective traction was obtained with the Bell table than with the Cox device. The results with the sagittal pin fixation and slipper cast were, in my opinion, superior to those following treatment with the conventional Boehler method.

In time, however, some extremely comminuted fractures were encountered. In these it was believed that reduction could not possibly be held with a single sagittal pin. For this reason, beginning in August of 1942, an alternative method of treatment was gradually developed which, as far as possible, preserves the advantages of the Cox method.

DESCRIPTION OF THE METHOD

Reductions are performed as soon as possible unless swelling is already excessive or bleb formation is advanced when first seen. After the usual skin preparation of soap and water, alcohol and ether, the patient is placed upon his abdomen on the Bell table. The Steinmann pins used are $5/32$ of an inch in diameter. The first pin is drilled transversely through the posterior superior angle of the os calcis. Particular care is used in placing this pin, and a hypodermic needle may be used to locate the approximate point. This location is important due to the mechanical advantage gained. A small rotating stirrup (Boehler type) is attached to this pin, and the leg is loosely suspended with a muslin bandage tied to this stirrup to one of the windlass attachments to the overhead bar. Countertraction is afforded by the weight of the leg and by tying the thigh down to the foot bar of the table with a flannel bandage. A small pillow is placed in the popliteal space to protect the popliteal vessels. Another flannel bandage is tied behind the ankle and run to the foot piece. Traction on this band allows pull against the os calcis pin to give distraction in the long axis of the os calcis. To increase the arch of the foot and the tuber angle, another flannel band is run over the dorsum of the foot and this band is attached to the same windlass as is the os calcis pin (Fig. 1).

[1]Wilbur J. Cox. Description of method to be published.

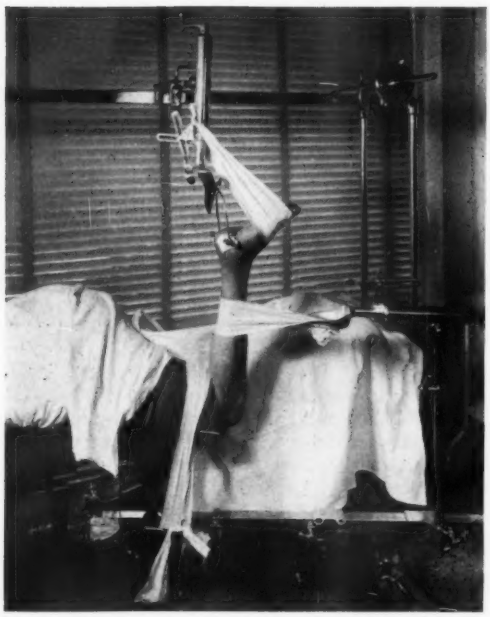

Fig. 1. Position of the patient upon the Bell table just before first x-ray films are taken to check reduction.

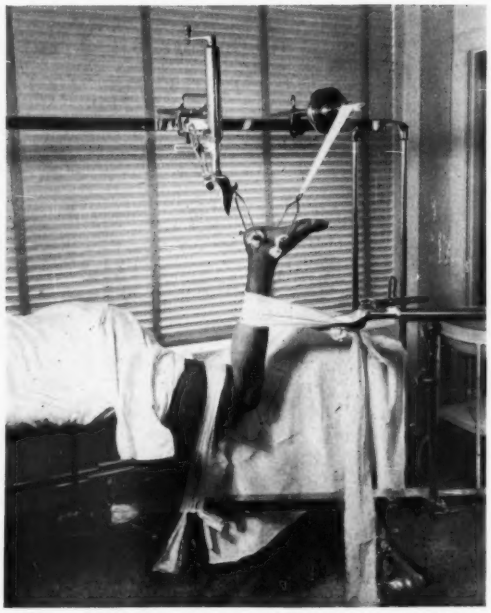

Fig. 3. Steinmann pins in position with traction being maintained.

Traction is then increased upon the os calcis pin until the heel cord is very tight and the arch of the foot apparently restored. The os calcis is then compressed laterally with the Boehler clamp. Three applications are made, special care being taken to compress the bone under the lateral malleolus. It should be noted here that the Boehler clamp should be improved by adding larger blades molded to conform to the configuration of the os calcis.

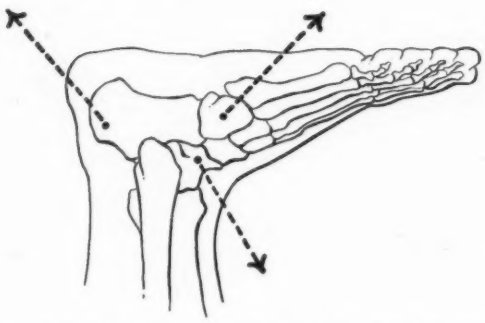

Fig. 2. Diagram to show points of pin insertion and approximate direction of pull.

Lateral and axial roentgenograms are then taken to check reduction. If it is seen that the fracture is transverse and not greatly comminuted, a Steinmann pin is driven under fluoroscopic control in a sagittal direction across the fracture site and cut off, the end extending 1 inch from the heel. The transverse pin is removed, and a slipper cast is applied incorporating the sagittal pin.

If, however, the fracture is seen to be comminuted and not likely to be held by a single pin sagitally placed, the other two transverse pins are inserted. The first pin is drilled through the neck of the astragalus from the medial side of the foot at a point just below the tip of the medial malleolus and one finger breadth anterior to it. Another pin is drilled through the cuboid from the lateral side of the foot at a point just above the base of the fifth metatarsal (Fig. 2). A rotating stirrup is then applied to this pin, and it is attached to another windlass on the overhead bar. Traction is placed on this pin in an upward and anterior direction (Fig. 3).

A nonpadded cast is applied incorporating the three pins, sheet wadding being placed only around the ankle and metatarsal heads (Fig. 4). While the plaster is hardening, forcible lateral pressure is made upon the os calcis with the heels

of the hands. Particular care is taken to secure compression beneath the lateral malleolus. The use of a cast is very necessary to secure this compression. The cast is cut out to allow free ankle motion as well as behind the metatarsal heads to allow free toe motion. It should be split over the dorsum of the foot, especially in those cases reduced immediately after fracture. The extending portions of the pin through the astragalus and navicular should be cut off close to the cast. The stirrup is left attached to the pin through the os calcis, and in the ward, 3 to 5 pounds of traction should be applied. This is a most important step in the treatment, since if not done, the foot will fall into equinus which is difficult to correct. This fact was noted in the early cases. It is believed to be the result of spasm of the heel cord following the painful fracture.

From the beginning the patient is encouraged to do dorsiflexion and toe motion exercises. After 3 to 5 days, the tendency for equinus ceases and the soreness of the foot is entirely gone. Traction is then removed and the pin through the os calcis is cut off flush with the cast (Fig. 5). The patient is then allowed up on crutches and discharged from the hospital. He is carefully instructed to continue with the exercises and to elevate the foot during the day if edema occurs.

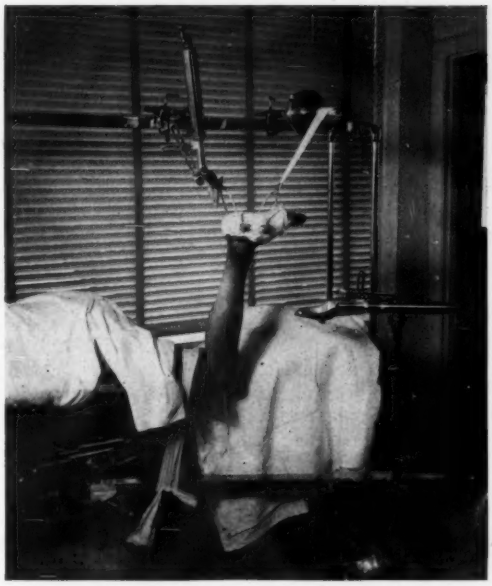

Fig. 4. The cast has been applied while traction is still being maintained.

Six weeks after operation the cast and pins are removed. An elastic adhesive dressing or Unna paste boot is applied from the metatarsal heads to the upper ankle to prevent edema. Exercises are continued and in addition, the patient is instructed to begin inversion and eversion of the foot. Weight bearing is begun 8 weeks after operation. A metal arch support is worn in a heavy work shoe. The arch support is similar to any regular support except that the heel portion is removed and replaced with sponge rubber. The exercises are continued rigorously. Contrast baths are taken twice daily to control any remaining tendency toward edema during the early weight-bearing stage.

Under this regimen, excellent ankle and toe motion and very good subastragalar motion result. Many of these patients have returned to work as

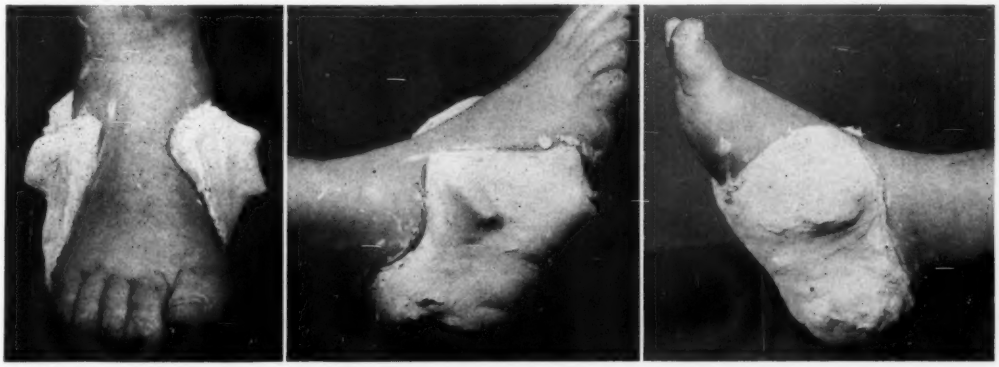

Fig. 5. The completed cast after the pin through the os calcis has been cut off flush and the patient is up and about on crutches.

early as 12 weeks from the date of reduction. There has been a surprising lack of edema and pain in the foot. In some cases mild subastragalar pain has occurred after work for 2 to 3 months. Thus far the patients have preferred working rather than losing time for triple arthrodesis. Nevertheless, it is probable that at least 50 per cent of these patients will need triple arthrodesis in the future. It is my belief, however, that the results after triple arthrodesis will be better in fractures treated initially by this method than in those treated initially by other methods. The restoration of the architectural height of the os calcis will allow satisfactory performance of this operation. In addition, the excellent general condition of the foot, the good muscle tone, and the good calcification of the bone with good ankle and toe motion without swelling and edema will promise better and earlier healing and weight bearing without tenderness.

No pin infections have been encountered in fractures treated to date except those in which slough of the skin was present before treatment was instituted. In these there was some drainage from the slough and the pins were removed as early as 4 weeks. Interestingly enough it should be noted that no loss of skeletal correction has followed in these instances.

CONCLUSIONS

The method of treatment described is believed by the author to offer many advantages over those now in common use. For the transverse fracture, the modification of the Cox sagittal pin method is undoubtedly superior. For the badly comminuted fractures, the three-pin method should be used. It is contended that superior architectural restoration is gained. In addition, there is less decalcification of the bones of the foot, less edema, and increased ankle and foot motion. Earlier and better functional results are seen. The method is comfortable and inexpensive in that hospitalization time is reduced.

While it is admitted that many patients will later need triple arthrodesis, it is believed that the improved condition of the foot and bone will permit better function after this operation than is usually seen.

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CONTROL OF PAIN IN POST-TRAUMATIC VASCULAR DISTURBANCES

AFTER trauma, complete recovery does not always follow in reasonable time. In a large group of patients disability persists abnormally long in spite of satisfactory anatomical healing; in spite of physiotherapy and other means to obviate the remaining symptoms. The conditions being discussed are so numerous and variable it is difficult to class them under one heading. Included are causalgia, sympathalgia, Sudeck's atrophy, value pains not strictly deserving designation by any of these terms; and in addition painfully stiff joints and ischemic contractures of the Volkmann type. These conditions do have two things in common, namely, pain persisting abnormally long, and vascular disturbances. The type of pain by its very indefiniteness is more or less common to all. It may be mild; it is frequently severe. It is often unlocalized, it is deep, segmental, diffuse and usually its pattern does not conform to the distribution of a sensory nerve. The pain resembles that of other vascular disturbances such as Raynaud's disease and the "rest pains" of thrombo-angiitis obliterans. The conditions included are not the immediate consequences of trauma, they are in that period of convalescence when the immediate reaction to trauma has since passed and healing of bone and soft tissue has occurred. The pain—for that is a constant symptom—may disable, but sometimes the objective evidence to support its actuality is so obscure the possibility of malingering may rightfully be entertained. In addition to these pains, however, the extremity may be colder than the opposite one, a condition detectible by the thermocouple if not by gross clinical examination. Other evidences such as edema, osteoporosis, and stiffness of joints and muscles may be more concrete evidences of vascular disturbance. Able investigators have found an increased flow of blood through the affected extremity, but have explained the disassociated diminished surface temperature by surmising a mixed vasodilatation and vasoconstriction. Whether this vascular disturbance is the cause of the pain is uncertain. However, induced vasodilatation usually has coincident dramatic relief of pain.

In 1915 Leriche performed a periarterial sympathectomy on the brachial artery for a vasomotor phenomenon associated with pain, cyanosis, and a cold extremity in a man who had had a bullet wound of the axilla. The burning pain was immediately relieved. This was a new approach to the relief of such pains. Since then, however, the rôle of the sympathetic nervous system in the posttraumatic syndrome has not been widely appreciated,

and measures to affect the pain by attacks on the sympathetic nerves are not in common use. Since Leriche's first case, he and others have called attention to the relief to be afforded by temporarily or permanently interrupting the sympathetic nervous system. Perhaps there are two reasons why this has not been widely accepted. First, there is no experimental proof from the lower animals and, second, it is generally taught that pain travels over sensory nerves only, and such doctrine, firmly imbedded in the minds of the profession, makes the suggestion of any other pathway for major pain one which is received with incredulity. That such pain can be relieved by interrupting the anatomic or functional continuity of sympathetic nerves is a fact which may repeatedly surprise those familiar with it by its dramatic completeness and is at times unbelievable to those without such previous experience.

Before the Southern Surgical Association in December, 1943, I reported a group of patients with posttraumatic vascular syndromes who were treated by temporary or permanent interruption of the sympathetic nerves. Some had preganglionic sympathectomies with good results. The majority, however, had planned, repeated paravertebral sympathetic nerve blocks with novocain. Following these blocks the extremity became warm, the pain was relieved temporarily. Joints which were so painfully stiff that they could not be moved before the block, could be forcefully moved after the blocks with very little pain. The next day the pain returned but with less and less intensity after each succeeding block. Nerve blocks were performed every other day or every third day for three to six times. The disabling pains finally failed entirely to reappear. Joints which had been stiff for several months and which resisted mobilization because of pain, were returned to normal function in a relatively short time. In one instance an early Volkmann's ischemic contracture with a stiff and painful arm was obviated by means of repeated sympathetic nerve blocks and physiotherapy.

To be effective the nerve block with novocain usually has to be performed repeatedly. In some instances permanent section of the sympathetic chain is indicated. The performance of paravertebral sympathetic nerve blocks in the dorsocervical or the lumbar region is not technically difficult, and with reasonable precaution and skill it is not at all dangerous.

The profession will probably accept and use such measures for the relief of persisting posttraumatic pains with more and more frequency and more gratifying success.

HOWARD MAHORNER.

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

THE only compend, or outline, of urology ever compiled which is so thorough and complete that it overcomes the usual objection to its own form is the one written by William H. Mencher.[1] In the words of the author, "It is hoped that this small volume will prove its worth as a refresher course for students, practitioners and specialists in urology; as a syllabus for lecturers and teachers; and as a companion work for the larger, more elaborate textbooks of urology."

I believe the author's hope has been more than realized, and I find myself constantly referring to this work, not only as an outline for teaching but frequently for a concentrated picture of a differential in diagnostic problems. VINCENT J. O'CONOR.

MANY new facts have been added to our store of information about backache during the past two or three decades, and the improvement in our understanding of this condition is but one index of the great advance that has been made in the whole field of orthopedic surgery during this time. Dr. Philip Lewin's book on *Backache and Sciatic Neuritis*[2] gives a faithful summary of all of these relatively new contributions to pathology, diagnosis, and treatment. The importance of the concept of bodily mechanics which has been so ably developed by Dr. Joel E. Goldthwait, and that of reflex pain which has been emphasized by Dr. Arthur Steindler are well set forth in a foreword by each of these authors as well as in the text of the book.

The subject is presented in separate chapters from the standpoint of military surgery and of industry. The newest contribution which has done so much to explain many cases of backache and sciatic pain, herniation of the nucleus pulposis, is well set forth. Other chapters treat of the anatomy of the spine and the variations in development which lay the background for many of these cases.

The reader is apt to be surprised by the multiplicity of subjects included in the book, among them fractures of the spine, wound healing, burns, gas gangrene, tuberculosis of the spine, scoliosis, torticollis, methods of lengthening the extremities, the Kenny treatment for poliomyelitis, and the scalenus syndrome. It is not until one reads the subtitle of the book and the table of contents that he realizes that this really is a veritable enclycopedia of all facts even remotely connected with all diseases, injuries, and tumors of the neck, back, and pelvis, as well as sciatic and brachial neuritis. So numerous are the items included that one who is not familiar with this subject is liable to become bewildered by their great array. It would seem to the reviewer that the book would be more useful to the general practitioner, for whom it was written, if the author placed more emphasis upon those methods of diagnosis and treatment that he has found to be helpful and important and had subordinated many of those which are not.

A very complete and valuable bibliography as well as a good index is given at the end of the book. ALAN DEFOREST SMITH.

THE entire field of medical radiological technique is presented in an orderly and well planned manner in *Medical Radiographic Technic*.[3] The photographs of the patients, and the diagrams of the position of the tube and the course of the x-ray through the patient with the resultant radiogram are especially good. All of the commonly used positions are illustrated. The theoretical and practical considerations of processing the films and also the description of what constitutes a good film are excellent. There are also chapters on photography of the fluorescent screen, foreign body localization, soft tissue radiology, and planography. The section on anatomy is adequate for the average technical procedures involved. The paper, printing, and illustrations are also of excellent quality.

If any criticisms could be made, they would be directed at the first 4 chapters where the theory of electronics is developed in a very rapid manner. These are supported by a large number of mathematical equations which are beyond the comprehension of the average technician. They serve to confuse rather than simplify the subject under discussion. The diagrams in this section, however, are excellent.

This book is recommended to both radiologists and technicians. R. G. WILLY.

THE original list of references compiled by the late Fielding H. Garrison appeared in the *Index-Catalogue* of the Surgeon General's Office in Washington in 1912, and was used by him as a "scaffolding" for his *Introduction to the History of Medicine*. A revision of this list, published in 1933 as *A Revised Students' Check List of Texts Illustrating the History*

[1] UROLOGY. By William H. Mencher, A.B., M.D., F.A.C.S. London, New York, and Toronto: Oxford University Press, 1942.

[2] BACKACHE AND SCIATIC NEURITIS; Back Injuries—Deformities—Diseases—Disabilities. With notes on the Pelvis, Neck and, Brachial Neuritis. By Philip Lewin, M.D., F.A.C.S. Philadelphia: Lea & Febiger, 1943.

[3] MEDICAL RADIOGRAPHIC TECHNIC. Prepared by The Technical Service Department of General Electric X-ray Corporation. Edited by G. W. Files, Director, Springfield, Ill., and Baltimore, Md.: Charles C. Thomas, 1943.

of Medicine is the basis of the present work.[1] Of Garrison's 4,186 entries Mr. Morton has retained 3,826 and added to them 1,680 new references which include important contributions made in the last decade and recently published histories. Author and subject indexes have been provided. By means of brief annotations the English librarian has indicated the significance of various contributions. The references are numbered consecutively and under each subject they are arranged in chronological order. In a volume of such relatively small size many references that might have been included have, of necessity, been omitted. The histories of special subjects usually found at the end of each section compensate for such omissions. This book makes available in convenient form the most valuable contributions to the history of medicine and its ancillary sciences. Offered as a "starting point to something better" it will be of undoubted value to librarians, bibliographers, students of the history of medicine, and to research workers. WALTER H. NADLER.

[1] A MEDICAL BIBLIOGRAPHY; A Check-List of Texts Illustrating the History of the Medical Sciences. Originally compiled by the late Fielding H. Garrison, revised with additions and annotations by Leslie T. Morton. London: Grafton & Co., 1943. (£ 2, 10s.).

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

TEXTBOOK OF GENERAL SURGERY. By Warren H. Cole, M.D., F.A.C.S. and Robert Elman, M.D. New York and London: D. Appleton-Century Company, 1944.

SMALL COMMUNITY HOSPITALS. By Henry J. Southmayd, and Geddes Smith. New York: The Commonwealth Fund, 1944.

INDUSTRIAL OPHTHALMOLOGY. By Hedwig S. Kuhn, M.D., St. Louis: The C. V. Mosby Company, 1944.

PROCEEDINGS OF THE CONFERENCE ON PROBLEMS OF HUMAN FERTILITY. Sponsored by the National Committee on Maternal Health, January 15–16, 1943, New York City. Edited by Earl T. Engle. Menasha, Wisconsin: George Banta Publishing Company, 1943.

FORSDIKE'S TEXTBOOK OF GYNAECOLOGY. By J. H. Peel, M.A., B.M., B.Ch. (Oxon.), F.R.C.S. Rev. enl. ed. New York: Grune and Stratton, 1944.

NARCO-ANALYSIS. A New Technique in Short-Cut Psychotherapy: A Comparison with Other Methods: And Notes on the Barbiturates. By J. Stephen Horsley. Oxford Medical Publications. London: Oxford University Press (Humphrey Milford), 1943.

A NATIONAL HEALTH SERVICE. Presented by the Minister of Health and the Secretary of State for Scotland to Parliament by Command of His Majesty. New York: The Macmillan Company, 1944.

CLINICAL CONGRESS OF AMERICAN COLLEGE OF SURGEONS

W. EDWARD GALLIE, Toronto, *President*
IRVIN ABELL, Louisville, *President-Elect*

Committee on Arrangements
WARREN H. COLE, *Chairman;* MARSHALL DAVISON, *Secretary*

PLANS FOR THE 1944 CLINICAL CONGRESS IN CHICAGO

AT a meeting of the Board of Regents held in Chicago on May 5 plans for the 1944 Clinical Congress of the American College of Surgeons, to be held in Chicago October 24–27, were approved. Thus the surgeons of this city will be privileged to act as hosts to a large group of their colleagues for the eighth time since the first meeting in 1910.

Under the leadership of a representative committee of Chicago fellows a clinical program is being prepared for presentation at the medical schools, affiliated teaching hospitals and other large hospitals, to include operative and nonoperative clinics, demonstrations, and exhibits conducted by the surgeons and other specialists connected with these institutions. All the special fields of surgery will be represented therein, affording the visiting surgeons an opportunity to study at first hand the latest advances in surgery as well as important experimental and research activities of Chicago institutions. The program will present a wide variety of material in the fields of general surgery, fractures and other traumas, neurosurgery, thoracic surgery, orthopedic surgery, urology, obstetrics and gynecology, ophthalmology, and otorhinolaryngology. Clinics and demonstrations at the hospitals will be held on Tuesday afternoon, October 24, and on the mornings and afternoons of the three following days.

The Congress will open at 9:30 on Tuesday morning with a general assembly in the Ballroom of the Stevens Hotel. The President of the College, Dr. W. Edward Gallie, of Toronto, will preside. Other speakers will include Dr. Irvin Abell of Louisville, Chairman of the Board of Regents, who will review the activities and accomplishments of the College during recent years. The Surgeons General of the Army, Navy, and Public Health Service will report on the accomplishments of their departments during nearly three years of war.

At the Presidential Meeting and Convocation on Tuesday evening in the Ballroom of the Stevens Hotel the new officers of the College will be inaugurated and initiates of the classes of 1942, 1943, and 1944 will be received into fellowship. Dr. W. Edward Gallie will deliver the presidential address at this session and distinguished visitors from foreign countries will be introduced. At scientific meetings on Wednesday, Thursday, and Friday evenings at headquarters eminent surgeons of the United States and Canada, and possibly visiting surgeons from foreign countries, will present papers on surgical subjects of timely importance. The programs are in preparation under the direction of the Board of Regents and will be published in a later issue.

The value of panel discussions as a medium for conveying information on selected topics has been amply demonstrated at previous Congresses and sectional meetings. Programs for a series of panel discussions dealing with new aspects of military and civilian surgery will be held daily during the Congress at which eminent surgeons will collaborate in the presentation of vitally important material. Opportunity will be afforded for free discussion of the subjects from the floor by those attending the panels.

It will be recalled that an important feature of Congresses held in years just prior to the war was the "Forum on Fundamental Surgical Problems" which it is expected will be given a place in the program. The purpose of the forum is to enable younger men representing university departments of surgery to present the important results of their clinical and experimental work.

Both military and civilian surgeons will participate in the demonstrations, panel discussions,

and formal scientific sessions on fractures and other traumas. Developments in the care of injuries suffered in civilian accidents, as well as those encountered in military action, will be featured.

Besides its interest to physicians caring for civilian patients, cancer is of increasing concern to those entrusted with the care of military personnel and veterans. The developments in diagnosis and treatment since the last Clinical Congress in 1941 will be covered as comprehensively as possible in this symposium.

The general program of the Congress includes many features of special interest to those surgeons whose practice is limited to ophthalmology or otorhinolaryngology. Operative clinics and demonstrations will be given daily at several of the hospitals. Programs for a series of clinical conferences and scientific sessions, all to be held at the headquarters hotel, are being prepared. Outstanding specialists will present papers of particular current interest and will lead the discussions. A series of selected motion pictures related to these special subjects will be exhibited.

The College is embarking upon an intensive program to stimulate the creation of more opportunities for graduate training in surgery and the surgical specialties, designed chiefly to meet the needs of returning military medical personnel who desire to resume their education which was interrupted by war service. Medical educators and chiefs of surgical staffs will discuss methods of carrying out the principles of the minimum standard of the College.

Concurrently with the Clinical Congress, the usual Hospital Standardization Conference will be held. Topics will be chosen which are of the greatest current interest to hospital administrators and other executive personnel. Among these will be post-war planning; rehabilitation, so far as its hospitalization aspects are concerned; the emergency maternity and infant care program; distribution of penicillin to civilians; re-employment of former employes upon their discharge from military service; and such other subjects as may assume importance in the coming months.

A daily presentation at headquarters of a varied program of surgical motion pictures is planned, to include the newest available films approved by the committee on medical motion pictures.

Meetings of the state and provincial Judiciary, Credentials, and Executive Committees will be held on Wednesday forenoon at headquarters with addresses by the President, officers of the College, and the Regents. The annual meeting of the Governors and fellows will be held in the Ballroom of the Stevens Hotel on Thursday afternoon beginning at 1:30.

The hospitals of Chicago afford accommodations for a large number of visiting surgeons, but attendance at the Congress will be limited to a number that can be comfortably accommodated. Surgeons who expect to attend the Congress will therefore register in advance. Admission to clinics at the hospitals and to certain scientific sessions at headquarters will be controlled by means of tickets issued to the visiting surgeons at the registration desk.

In accordance with a resolution adopted by the Board of Regents, fellows of the College whose dues are paid to December 31, 1943, initiates of the class of 1944, and fellows in military service will not be required to pay a registration fee. For endorsed junior candidates the fee is $5.00; for surgeons who are not fellows, attending as invited guests of the College, the fee is $10.00.

Headquarters for the Congress will be established at the Stevens Hotel which affords unusual facilities for so large a meeting as the Congress. The public rooms on the second and third floors have been reserved for scientific sessions, conferences, and panel discussions. The Technical Exhibition, together with the registration desk, will be located in the large Exhibit Hall on the lower floor of the hotel where leading manufacturers of surgical instruments, sutures, dressings, pharmaceuticals, operating room equipment, x-ray apparatus and hospital equipment of all kinds, as well as publishers of medical books, will be represented in the exhibition.

Chicago has many first class hotels, several within walking distance of headquarters. Reservations for hotel accommodations should be made at the earliest possible date. The following hotels are recommended:

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	Single	Double
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Chicagoan, 67 W. Madison St.	2.75	4.40
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Eastgate, 162 E. Ontario St.	2.75	4.40
Edgewater Beach, 5349 Sheridan Road.	4.40	6.60
Harrison, 57 E. Harrison St.	2.00	3.00
Knickerbocker, 163 E. Walton Place.	3.50	5.00
LaSalle, Madison and LaSalle Sts.	2.75	4.40
Medinah Club, 505 N. Michigan Ave.	3.50	5.00
Morrison, 79 W. Madison St.	2.75	4.40
Palmer House, 15 E. Monroe St.	3.85	5.50
Planters, 19 N. Clark St.	2.25	3.50
St. Clair, 162 E. Ohio St.	3.00	4.50
Seneca, 200 E. Chestnut St.	4.00	6.00
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Stevens, 720 S. Michigan Ave.	3.25	5.00

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THE RADIUM EMANATION CORPORATION

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